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evaluation of
rapeseed derived
biodiesel fuels

SwRI 7507

# EMISSIONS AND LUBRICITY EVALUATION OF RAPESEED DERIVED BIODIESEL FUELS

By

Christopher A. Sharp

FINAL REPORT

Prepared for

MONTANA DEPARTMENT OF
ENVIRONMENTAL QUALITY
P.O. Box 202301
Helena, Montana 59620

November 1996

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FINAL REPORT

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November 1996

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# EXECUTIVE SUMMARY

Two different biodiesel fuels derived from rapeseed oil were tested at Southwest Research Institute (SwRI) to characterize heavy-duty engine exhaust emissions and biodiesel effects on lubricity. The objective of the program was to compare results for the biodiesel fuels to results obtained with diesel fuel. The two biodiesel fuels were a rapeseed ethyl ester (REE) and a rapeseed methyl ester (RME). Each fuel was tested both neat and in two blend levels, 50 percent and 20 percent by volume with the base diesel fuel. The transient emissions characterization was performed using a 1995 Cummins B5.9L diesel engine, both with and without a catalytic converter (catalyst).

Composite transient emissions data for the four primary pollutants, regulated by the EPA for on-highway engines, is given in the table below. Emissions data are given for all seven test fuels, both with and without catalyst. Transient cycle work and fuel consumption data (BSFC) were also included. In general, the biodiesel fuels reduced transient emissions levels of HC, CO, and total particulate, but had no significant effect on $NO_x$ levels, as compared to levels obtained with diesel fuel.

## COMPOSITE EMISSIONS FROM A CUMMINS B5.9L ENGINE WITH BIODIESEL FUELS

| Fuel | Catalyst | Transient Emissions, g/hp-hr | | | | | BSFC, lb/hp-hr | Work, hp-hr |
|---|---|---|---|---|---|---|---|---|
| | | HC | CO | $NO_x$ | $CO_2$ | PM | | |
| 2-D | No | 0.30 | 1.47 | 4.37 | 609 | 0.106 | 0.424 | 12.5 |
| | Yes | 0.25 | 1.42 | 4.25 | 606 | 0.073 | 0.422 | 12.4 |
| REE | No | 0.11 | 0.95 | 4.26 | 645 | 0.091 | 0.500 | 11.7 |
| | Yes | 0.07 | 0.64 | 4.27 | 651 | 0.047 | 0.505 | 11.7 |
| RME | No | 0.09 | 0.90 | 4.52 | 642 | 0.080 | 0.498 | 11.8 |
| | Yes | 0.06 | 0.61 | 4.48 | 640 | 0.042 | 0.494 | 11.8 |
| REE50 | No | 0.17 | 1.03 | 4.26 | 621 | 0.092 | 0.458 | 12.2 |
| | Yes | 0.12 | 0.74 | 4.37 | 637 | 0.058 | 0.470 | 12.1 |
| RME50 | No | 0.16 | 0.97 | 4.30 | 625 | 0.087 | 0.460 | 12.2 |
| | Yes | 0.11 | 0.70 | 4.30 | 633 | 0.055 | 0.458 | 12.2 |
| REE20 | No | 0.23 | 1.24 | 4.31 | 623 | 0.100 | 0.444 | 12.2 |
| | Yes | 0.16 | 0.94 | 4.30 | 645 | 0.067 | 0.459 | 12.2 |
| RME20 | No | 0.22 | 1.14 | 4.39 | 618 | 0.093 | 0.444 | 12.2 |
| | Yes | 0.15 | 0.97 | 4.33 | 616 | 0.064 | 0.442 | 12.2 |

Particulate samples from all transient emission tests were analyzed to determine the composition of the particulate. These data indicated that the reductions observed in particulate emissions when biodiesel fuels were used were due primarily to reduction in the level of carbon soot. Reduced carbon soot probably resulted from improved oxidation of soot in the engine due to the oxygen present in biodiesel. However, the mass of volatile organic material in the particulate, referred to as the volatile organic fraction (VOF), increased when using biodiesel. The net decrease in total particulate using biodiesel fuels would have been larger but the increase in VOF partially offset the reduction in soot. An exhaust catalyst typically reduces the VOF of the particulates. Using biodiesel, the catalyst was able to control the increase in VOF, so that the combined use of biodiesel and a catalyst proved more effective in controlling particulate than either of the two alone. RME had slightly lower levels of regulated emissions than REE.

A disadvantage of the biodiesel fuels was noted in terms of engine performance and fuel economy (BSFC). The engine produced about 6 percent less power when fueled on either of the neat biodiesel fuels, and had significantly higher fuel consumption during the transient cycle. This change was less pronounced with the biodiesel/diesel fuel blends. The performance and fuel economy of the 20 percent blends were nearly identical to that of diesel fuel, whereas the 50 percent blends fell about halfway between the neat biodiesels and diesel fuel. These changes in performance and fuel economy were essentially due to the lower energy content per unit volume of biodiesel as compared to diesel fuel.

Sampling and analysis were also performed on all of the transient tests to try to characterize the compounds present in the gaseous hydrocarbon emissions in more detail. This data indicated that the neat biodiesel fuels appeared to reduce both the total mass and the reactivity, in terms of ozone formation potential, of the gaseous hydrocarbon emissions. It also indicated that the gaseous hydrocarbon emissions associated with using the neat biodiesel fuels were composed of a much narrower range of compounds than was the case for diesel fuel, and that apparently these compounds were more easily oxidized by the catalyst. The results for blended fuels generally followed a pattern similar to that observed for the neat biodiesel fuels, but to a lesser degree as the amount of biodiesel in the blend decreased. The hydrocarbon speciation data for the blends also indicated that the combination of diesel fuel and biodiesel did not produce any unusual toxic compounds not already found in the exhaust of either fuel when run separately.

Detailed analyses of both gaseous and particulate emissions were also made to determine the levels of polycyclic aromatic hydrocarbons (PAH). Gas-phase PAH levels significantly decreased with neat biodiesel fuels as compared to diesel fuel. Some of the particulate-phase PAH compounds also decreased, but several others increased. These same trends were present with the blended fuels, but less

strongly than with neat biodiesel fuels. In the case of PAH emissions, the 20 percent blends gave results essentially identical to the diesel fuel. It should be noted that the mass of gas-phase PAH compounds was several orders of magnitude higher than the mass of particulate-phase PAH compounds. The catalyst appeared to be effective in reducing PAH emissions from all fuels, but it was somewhat more efficient in doing so when the biodiesel fuels were used. The catalyst was also able to control any increases in particulate-phase PAH compounds that occurred when biodiesel was used.

Lubricity testing of the biodiesel fuels was performed on laboratory scale wear testing machines, using two different methods. The test results indicated that both neat RME and REE had excellent lubricating characteristics, superior to any known commercially available diesel fuel. Tests also indicated that blending biodiesel with conventional diesel fuel resulted in a significant improvement in lubricity as compared to the diesel fuel alone.

# I. INTRODUCTION

This final report contains the results of testing conducted at Southwest Research Institute (SwRI) on behalf of the Montana Department of Environmental Quality (DEQ). The work reported herein constitutes Milestones 2 and 3 of a larger DEQ program (contract EDG-93-7549) for which the objective was to characterize engine emissions on two biodiesel fuels derived from rapeseed oil, and to examine the lubricating properties of the two fuels. The two biodiesel fuels examined were a rapeseed methyl ester (RME) and rapeseed ethyl ester (REE). These two fuels were examined in comparison to a typical 2-D diesel fuel, both as neat fuels and as blend components with 2-D diesel fuel.

For Milestone 2, exhaust emissions of a Cummins B5.9L diesel engine were examined using REE and RME, both neat and in blends. Both regulated and unregulated exhaust emissions were characterized, including PAH compounds and hydrocarbon species from $C_1$ through $C_{22}$. Emissions were measured both with and without a catalytic converter, which was supplied with the engine by Cummins Engine Company. Milestone 3 focused on performing several standard wear tests to evaluate the lubricating properties of both the neat biodiesel fuels and the biodiesel blends for comparison to 2-D diesel fuel.

The primary contact for this program at the DEQ was Howard Haines. Project oversight was provided by Craig Chase, who served as technical consultant for DOE, which provided major funding for this program. Biodiesel test fuels were produced at the University of Idaho, under the supervision of Dr. Chuck Peterson. The test engine and catalyst were provided by Cummins Engine Company. Lead project engineer at SwRI was Christopher Sharp. Most of the chemical analysis, was overseen by Patrick Merritt, except for PAH analysis which was performed by Joseph Pan. Lubricity testing was performed by Paul Lacey.

# II. DESCRIPTION OF PROGRAM

This section of the final report contains a description of the test engine, test fuels, and test procedures used during this program.

## A. Test Engine

The test engine used for this program was a 1995 model year Cummins B5.9L diesel engine. This engine was a four-stroke, six cylinder diesel of in-line configuration, having a displacement of 5.9 liters. The engine was turbocharged and intercooled, and employed a mechanically governed, in-line, fuel injection pump. Engine control input was achieved via a mechanical linkage between the injection pump pedal lever and the test cell servo controller. The engine had a nominal rated maximum power of 160 hp at 2500 rpm, and a nominal peak torque of 400 lb-ft at 1600 rpm. It was supplied with a stock catalytic converter, which was an oxidation catalyst produced by Engelhard. The catalyst was installed in the exhaust, six feet downstream from the turbocharger outlet. Figure 1 shows the engine installed in the transient test cell.

## B. Test Fuels

A total of seven different test fuels were evaluated during this program. Table 1 gives the descriptions of the seven fuels, as well as selected properties of those fuels, as determined by SwRI using standard ASTM test methods. The diesel fuel used during this program, both for baseline emissions testing and as the base fuel for blending, was a 1994 emissions grade, low sulfur, 2-D diesel fuel produced by Phillips Petroleum, Lot No. S-946X, coded SwRI EM-2140-F. The two biodiesel fuels were a rapeseed ethyl ester (REE) and a rapeseed methyl ester (RME), derived from rapeseed oil using transesterification with ethanol and with methanol. Both biodiesels were produced by the University of Idaho.

The blended fuels were produced at SwRI using the following methodology. First, density was measured for all three blend components, 2-D diesel fuel, REE, and RME. These densities were used to determine the correct mass proportions needed to obtain the appropriate volume fraction of each component for the four desired blends. The blends were then produced individually, on a drum-by-drum basis, using a calibrated weigh scale with an accuracy to ±0.1 grams. Each drum was then placed on a drum roller for a minimum of one hour, for mixing. The API gravity of each drum mixture was checked against the predicted API gravity, which was based on the volume proportions of the blend recipes and the API gravity of each blend component. The difference between API gravity of each drum of fuel

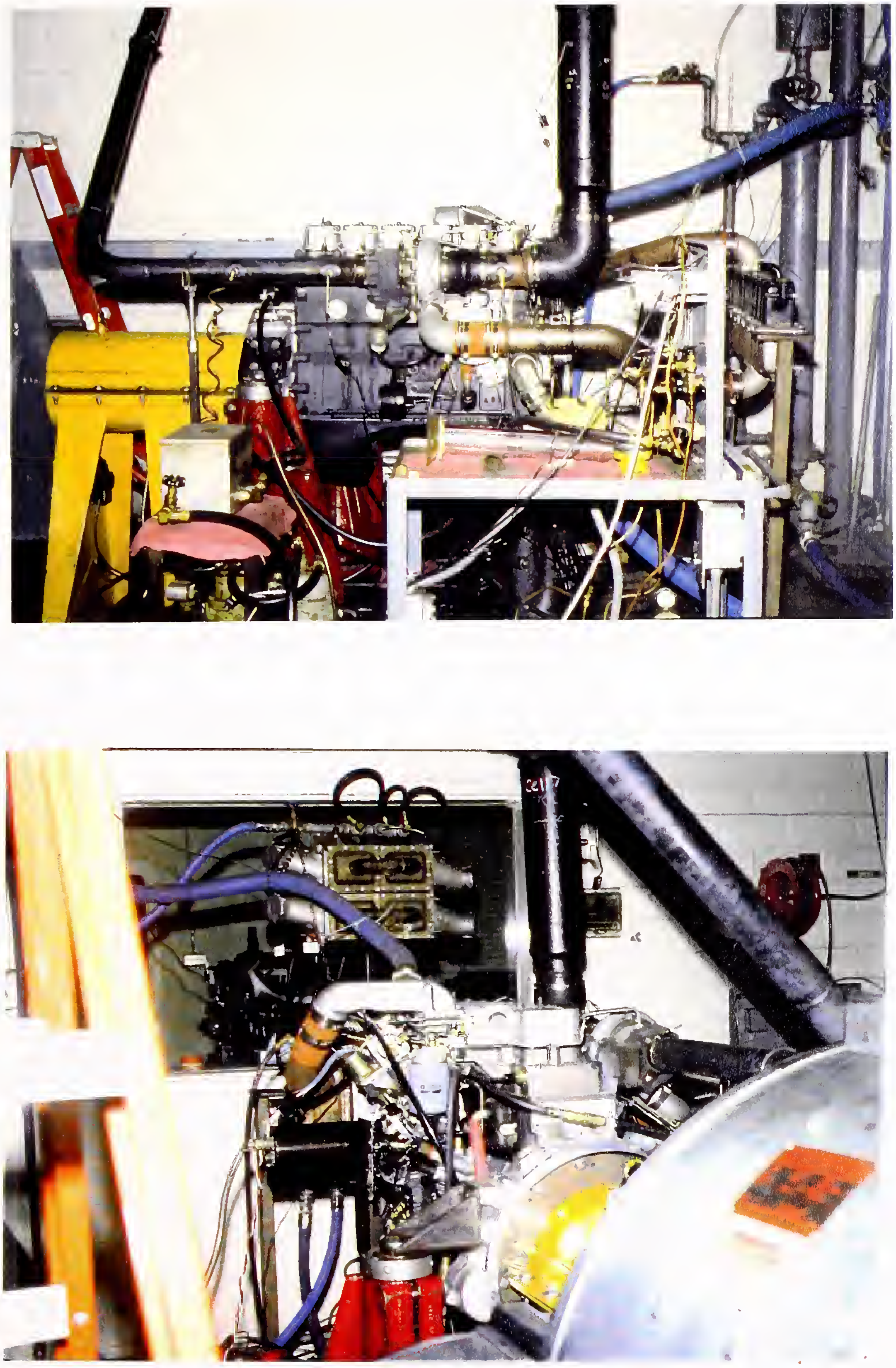

FIGURE 1. TRANSIENT TEST CELL INSTALLATION OF THE CUMMINS B5.9L ENGINE FOR BIODIESEL TESTING

# TABLE 1. PROPERTIES OF TEST FUELS FOR MONTANA DEQ BIODIESEL PROJECT

| Fuel | 2-D | REE | RME | REE50 | RME50 | REE20 | RME20 |
|---|---|---|---|---|---|---|---|
| Description | Diesel | Neat REE | Neat RME | 50% REE 50% 2-D | 50% RME 50% 2-D | 20% REE 80% 2-D | 20% RME 80% 2-D |
| Fuel Code | EM-2045-F | EM-2126-F | EM-2130-F | EM-2134-F | EM-2136-F | EM-2135-F | EM-2137-F |
| Cetane Number, D-613 | 43.3 | 60.7 | 58.7 | 50.8 | 51.0 | 48.2 | 48.2 |
| Distillation, °F, D-86: | | | | | | | |
| IBP | 343 | 643 | 462 | 370 | 373 | 341 | 347 |
| 0.1 | 433 | 681 | 569 | 477 | 475 | 443 | 442 |
| 0.5 | 501 | 705 | 696 | 615 | 613 | 525 | 525 |
| 0.9 | 591 | 747 | 725 | 694 | 698 | 676 | 662 |
| EP | 633 | 763 | 761 | 714 | 709 | 687 | 696 |
| API Gravity, D-4052 | 36 | 30.2 | 29.4 | 33.1 | 32.7 | 34.9 | 34.7 |
| Total Sulfur, wt%, D-2622 | 0.03 | <0.001 | <0.001 | 0.013 | 0.012 | 0.022 | 0.021 |
| Flashpoint, °F, D-1319 | 157 | 406 | 392 | 187 | 183 | 157 | 172 |
| Viscosity, cSt, D-445 | 2.63 | 6.07 | 5.51 | 4.05 | 3.80 | 3.13 | 3.02 |
| Carbon, wt%, D-5291 | 86.9 | 78.2 | 77.7 | 81.9 | 82.1 | 84.8 | 84.2 |
| Hydrogen, wt%, D-5191 | 13.1 | 12.6 | 12.4 | 12.6 | 12.8 | 13.2 | 13.1 |
| Oxygen, wt%, remainder | 00.0 | 9.2 | 9.9 | 5.5 | 5.1 | 2.0 | 2.7 |
| Heat of Combustion, Btu/lb, D-240 | | | | | | | |
| Gross | 19572 | 17483 | 17362 | 18516 | 18459 | 19131 | 19131 |
| Net | 18351 | 16336 | 16229 | 17365 | 17288 | 17930 | 17936 |
| Ash Content, D-482 | 0.001 | 0.001 | 0.003 | 0.005 | 0.005 | 0.002 | 0.003 |
| Carbon Residue, Ramsbottom, D-524 | 0.1 | a | 0.458 | a | 0.107 | 0.077 | 0.056 |
| Cloud Point, °C, D-2500 | -15 | -4 | -6 | -8 | -8 | -14 | -18 |
| Pour Point, °C, D-97 | -21 | -18 | -12 | -21 | -21 | -21 | -21 |

[a] Duplicate analyses on three different samples provided inconsistent results. No value is reported.

and its predicted API gravity was found to be less than 0.2°API in all cases. After the blending was complete, samples of all seven test fuels were pulled for analysis of the properties given in Table 1.

## C. Test Procedures

### 1. Transient Testing and Regulated Emissions Measurement

Emissions were measured over the heavy-duty transient Federal Test Procedure (FTP), following procedures given in CFR Title 40 Part 86, Subpart N. The FTP outlines specific requirements for setting up the test engine and mapping the engine's full torque capabilities over its operating speed range. Engine-specific performance data are used, along with a normalized EPA transient cycle, to define a transient command cycle for test engine operation. The 20 minute transient command cycle illustrated in Figure 2 shows the rapid changes in speed and torque the engine must produce.

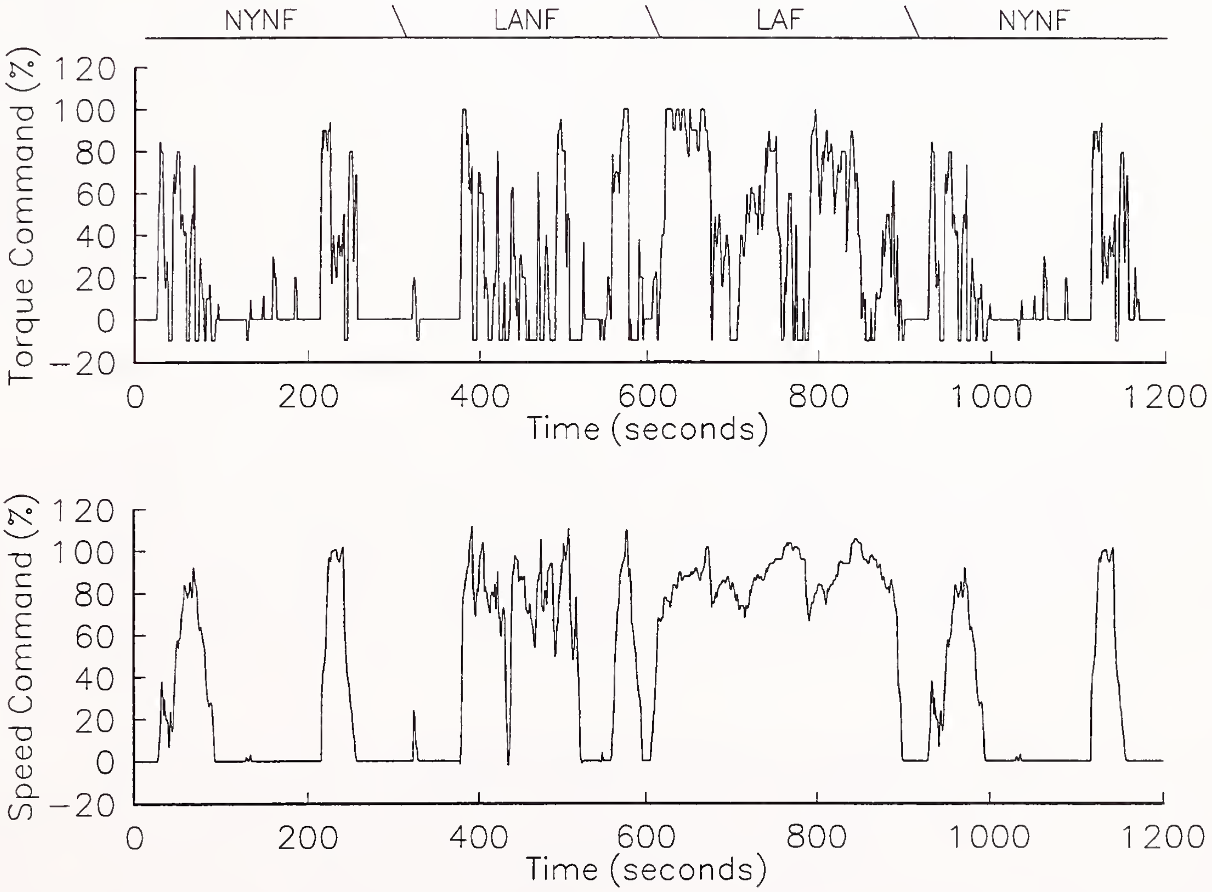

**FIGURE 2. GRAPHIC REPRESENTATION OF THE HEAVY-DUTY TRANSIENT CYCLE**

While the engine operated over the 20-minute test cycle, torque and speed responses of the engine compared to the command cycle to ensure FTP compliance. Simultaneously, engine exhaust gases are diluted with conditioned air, and emissions of interest are determined. Measured emissions are divided by the level of work performed during the test, and the heavy-duty engine emissions are reported in terms of pollutant mass per unit work.

Emissions measured during this program included total hydrocarbons (THC), carbon monoxide (CO), oxides of nitrogen ($NO_x$), and particulate matter (PM). Hydrocarbons were measured using continuous sampling techniques employing a heated flame ionization detector (HFID). CO and $CO_2$ were determined using proportional dilute gaseous samples analyzed using non-dispersive infrared (NDIR) instruments. $NO_x$ was measured continuously during the transient cycle via an $NO_x$ chemiluminescence instrument. Particulate samples were collected and analyzed to determine the soluble organic fraction (SOF), and the amount of sulfates in the particulate.

Total PM levels were determined by collecting particulate matter on a set of 90mm Pallflex filters, which were weighed both before and after the transient test. Soluble organic fraction (SOF) was determined by analyzing particulate samples collected on the 90mm filters via Soxhlet extraction, using a 30-70 mixture of toluene and ethanol as the solvent. Sulfates were determined by analyzing samples of particulate collected on 47mm Fluoropore filters with an ion chromatograph. Direct filter injection gas chromatography (DFI/GC) applied to a piece of the particulate-laden 90 mm filter was used analyzed to determine volatile organic fraction (VOF) and the contribution of unburned lubricating oil to that VOF.

### 2. Hydrocarbon Speciation

Detailed speciation analysis was conducted on the hydrocarbon emissions from the cold-start test and the first hot-start test for each day of emissions testing. Two different analyses were conducted, each dealing with a different carbon number range of hydrocarbons. The two ranges examined were $C_1$ to $C_{12}$ hydrocarbons, and $C_{13}$ to $C_{22}$ hydrocarbons. Each is discussed separately below.

The $C_1$ to $C_{12}$ hydrocarbons were analyzed from the same proportional bag samples of dilute exhaust used to determine CO and $CO_2$ emissions. Methods for speciating hydrocarbon emissions in this lower carbon number range are well defined, and involve using several gas chromatographs, each set up for a different subset of carbon number range, to quantify levels of about 200 gaseous hydrocarbons. Aldehyde and ketone emissions were determined as part of this process using a DNPH method as described in CFR 40

Part 86 Subpart N for methanol-fueled engines. Each hydrocarbon has been assigned a "maximum incremental reactivity" (MIR) by CARB. This factor represents the relative reactivity of a given species in generating ozone in the atmosphere, which is a precursor to photochemical smog. Using these MIRs, it is possible to estimate the amount of ozone the total hydrocarbon emissions will generate per unit of work the engine produces.

Identifying heavier hydrocarbons is more difficult, both in terms of sampling and analysis. Beginning with approximately $C_{13}$ compounds, the boiling points and vapor pressures of the species are such that they will not remain in the gaseous state unless maintained at elevated temperature. It is not practical to keep gaseous samples at elevated temperatures until analysis, so an alternate sample collection scheme was necessary. Sample collection was accomplished by drawing CVS-diluted exhaust through sorbent tubes packed with a solid sorbent material which has an extremely large surface area. The sorbent tubes are constructed of stainless steel tubing packed with this powdered solid sorbent material, held in place with small end plugs of glass wool and stainless steel screen. The sorbent material used in this project was Tenax GR®, useful for capturing hydrocarbons in the mass range of interest. Tenax GR® is also hydrophobic, so it is a good choice for sampling exhaust, which is very humid. Excess water can be a problem with some sorbents because preferential adsorption of water can displace sample molecules. Molecules making up the sample adsorb on the Tenax GR® at ambient temperatures, and can be subsequently desorbed by heating the sorbent material.

The sampling system is depicted in Figure 3. Exhaust samples were collected continuously during the test cycle. The temperature of the sampling system up to the sorbent tubes is maintained at 375°F to prevent condensation of analyte molecules. Before reaching the sorbent tubes, the sample passes through heated, flip-top filter holders fitted with glass fiber particulate filters.

For analysis, samples are thermally desorbed onto a 60m long x 0.32 mm diameter, 1μm film DB-1 gas chromatograph column coupled to a quadrupole mass spectrometer (GC/MS). A thermal desorption autosampler is used to heat the sorbent tube to 300°C while the inert carrier gas, helium, purges the sample from the tube. The sample tube is purged onto a cold trap for 20 minutes where the sample is subsequently caught on a cold trap maintained at 0°C. At this point the cold trap is ballistically heated to 300°C, introducing the sample onto the GC column all at one time. The mass spectrometer is operated in full scan mode, resulting in spectra that can be compared to a database of over 138,000 reference spectra. A computer algorithm is used to rapidly compare the unknown spectra against those in the database, and to rank them on the degree of fit. A chemist may then make a final determination as to the unknown compound's identity.

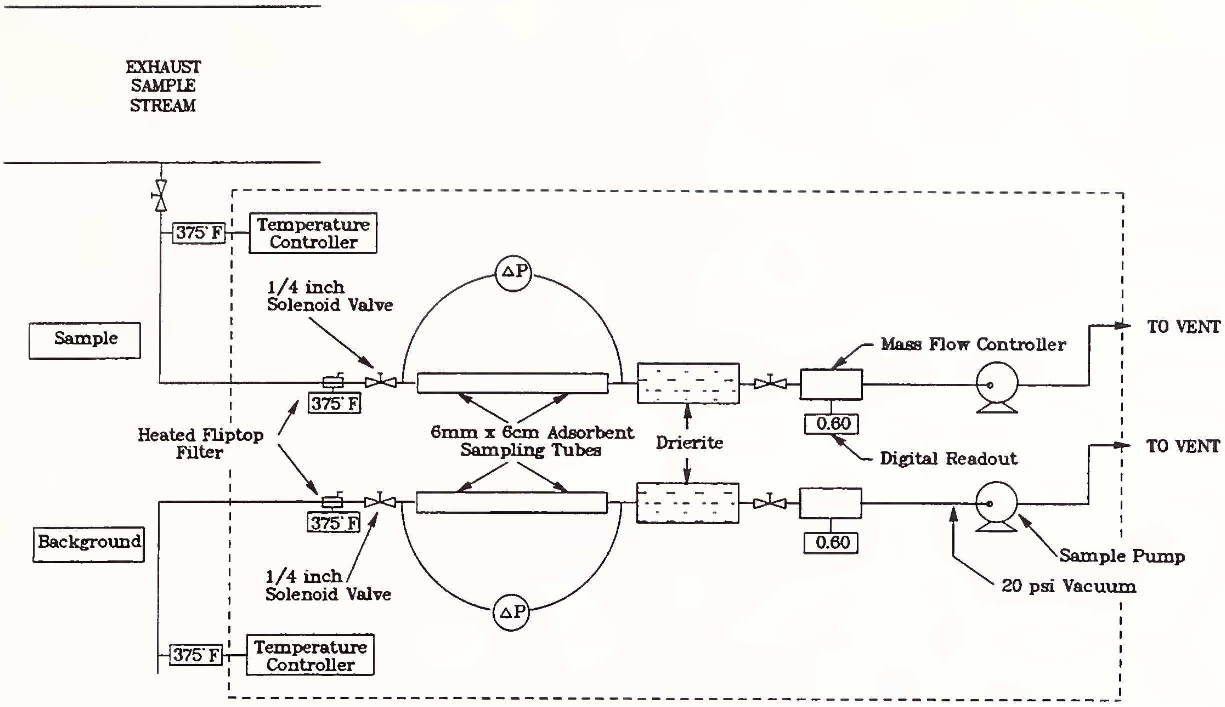

**FIGURE 3. SCHEMATIC OF MASS SPECTRAL ANALYSES SAMPLING SYSTEM**

Because the mass spectrometric analysis of the components of diesel exhaust is not well developed, the information gained from this work is largely qualitative. Any quantitative information is limited to discussion of relative amounts in a particular sample. This limitation stems from the fact that to accurately quantify particular compounds, one must have pure samples of the compound on hand to make up quantitative reference standards. Such effort was beyond the scope of this research.

## 3. PAH Analysis

Polycyclic aromatic hydrocarbons (PAH) were sampled using both a polyurethane foam (PUF) and a 20×20-inch Pallflex filter. This was done to insure collection of both gas phase and particulate phase PAH compounds. Details of the sampling and analysis of both media are given below.

Polyurethane filters (PUFs) were prepared for sample collection by extracting them with acetone for 24 hours, hexane for 48 hours, and then acetone again for 24 hours. The cleaned PUF is then blown dry under nitrogen for 12 to15 hours. One hundred µL of a surrogate solution containing fluorene-d10, fluoranthene-d10, and pyrene-d10 at a level of 20 ng/µL was spiked to both the

PUF and filter media following cleanup to monitor collection efficiency. The concentration at final volume was 2.0 ng/µL.

Exposed PUF and filter media were stored at 4°C following sampling and prior to extraction. The holding period did not exceed 4 days. PUF media were extracted with hexane:diethyl ether (94:6) by continuous Soxhlet extraction for 16 to 20 hours. Filter media were extracted with toluene by Soxhlet continuous extraction for 18 hrs. Solvents used were ultra high purity Fisher Optima® quality. One hundred µL of a surrogate solution containing 4,4'-dibromobiphenyl, anthracene-d10, and p-terphenyl-d14 at a level of 20 ng/µL was spiked to the media just prior to extraction, to monitor extraction efficiency. The concentration at final volume was 2.0 ng/µL.

Extracts were concentrated by transferring to Kuderna-Danish apparatus and heating over a steam bath to a volume of several mL. Quantitative transfer of the extract to vials followed, then further concentration with a stream of nitrogen until a final volume of 1 mL was reached. Sample extracts were stored at 4°C. Matrix spike analyses were made by spiking a blank sample (solvent only) with a solution of all target analytes, at a mid-level concentration of 1 ng/µL in the final extract, and treated in the same manner as the sampling media.

No cleanup procedures were performed on the sample extracts. PUF extracts were sufficiently clean that a cleanup step was not needed. Filter extracts contained some debris and would have possibly benefitted from a cleanup step; although analysis at a 10-fold dilution appeared to resolve most interference issues, and was required in most cases to reduce the level of analytes to the calibrated range of the MS.

GC/MS analysis was performed on a quadrupole instrument operated in selected ion monitoring (SIR) mode. Separation of PAHs was accomplished by injecting a 1 uL aliquot of the sample extract onto a 60 m DB-5 capillary column. For quantitation, an internal standard solution, made up of several deuterated PAHs, was spiked into the extract at the time of analysis and was used for calculating response factors. A linearity criterion of 30% RSD was used for a multi-point calibration curve established over the range from 0.01 to 10 ng/µL (0.01 to 10 total µg/sample).

PUF extracts were analyzed without dilution, whereas most filter extracts were sufficiently concentrated or high in PAHs that a 10-fold dilution was needed. While the established quantitation limit was 0.01 µg/sample, the sensitivity in SIR mode improved the lower detection limit by a factor of five for all PAHs, with the exception of nitropyrene.

## 4. Lubricity Testing

Laboratory scale wear tests were performed using two different experimental methods, the High Frequency Reciprocating Rig (HFRR) and the Scuffing Load Ball on Cylinder Lubricity Evaluator (SLBOCLE). Each of these two test procedures is described below.

The SLBOCLE determines the minimum applied load required for a step transition to adhesive scuffing. During testing, the fluid is placed in a humidity-controlled chamber. A non-rotating steel ball is held in a vertically mounted chuck and forced against an axially mounted polished steel ring. A sequence of one-minute tests is done, and the applied load is systematically changed until a disproportionate change in friction and wear is observed. The fuel is not renewed between load increments during a normal test sequence. The test cylinder is rotated at a fixed speed while being partially immersed in the fluid reservoir. This partial immersion maintains the cylinder in a wet condition and continuously transports the test fluid to the ball/cylinder interface. The minimum applied load required to produce a transition from sliding contact to severe friction and wear is a measure of the fluid-lubricating properties and this load is inversely related to wear.

The HFRR apparatus uses an electromagnetic vibrator to oscillate a moving specimen over a small amplitude while pressed against a fixed specimen. The fixed specimen is held in a small bath, which contains the test fuel. Bath temperature is controlled. The wear scar formed on the fixed specimen is measured and used to assess the lubricity of the test fuel. Provision is also made to measure the friction force transmitted between the two test specimens.

The conditions used for the wear tests in the present study are summarized in Table 2. Results obtained from both the SLBOCLE and HFRR test procedures show directional correlation with full scale equipment. For the SLBOCLE test, a minimum applied load more than 3,000 grams shows that, on average, a fuel is likely to produce acceptable wear in full-scale equipment. For the HFRR, a wear scar diameter of less than 0.38 mm indicates an acceptable fuel. However, both these values are unlikely to be absolute, and will vary as a function of fuel viscosity, operating temperature, and individual equipment requirements. As a result, most organizations have adopted different minimum fuel lubricity requirements, based on the application and the margin of safety needed.

## TABLE 2. SUMMARY OF CONDITIONS USED IN WEAR TESTS

| Variable | SLBOCLE | HFRR |
|---|---|---|
| App. Load, kg | 0.5–8.0 | 0.2 |
| Speed, rpm<br>Oscillation, Hz | 525 | <br>50 |
| Duration, min. | 1 | 75 |
| Break In, sec. | 30 | None |
| Atmosphere | Controlled Air | Uncontrolled |
| Humidity, %Rh | 50 | Ambient |
| Temperature, °C | 25 | Ambient |
| Pass/Fail* | 3.0 kg | 0.38mm |

*Tentative Value

# III. TEST RESULTS

This section of the report discusses results of the program in detail. It is broken down into sections to focus on individual areas of test results, including regulated transient emissions, hydrocarbon speciation, PAH analysis, and lubricity testing.

## A. Regulated Transient Emissions

This section presents the regulated emission results measured during transient testing of the Cummins B5.9L engine using all seven test fuels. It also includes the effect of the various fuels on the performance and fuel consumption of the engine. In addition, the results of DFI/GC, SOF, and sulfate analyses of particulate matter are also presented in this section. No smoke testing was performed during this program.

### 1. Base 2-D Diesel Fuel

The results of all transient tests are summarized in Table 3 for regulated emissions and $CO_2$, and Table 4 for particulate composition results. Detailed printouts of individual transient tests are given in Appendix A. Composite regulated emissions without catalyst for all seven fuels are depicted in Figure 4. The composition of particulate emissions is given in Figure 5 for all tests without the catalyst. Figure 6 shows the effects of the biodiesel fuels in terms of the percent reduction in emissions observed compared to 2-D fuel, without catalyst. Composite regulated emissions with the catalyst for all fuels are shown in Figure 7. Particulate composition for tests with the catalyst are shown in Figure 8. Figure 9 shows a comparison of biodiesel fuels to diesel fuel in percent difference with the catalyst installed. Figure 10 shows average transient torque-map data for all seven fuels.

Transient testing of the Cummins B 5.9L engine commenced on October 31, 1995 with the 2-D diesel fuel. Initial tests using 2-D fuel indicated that the engine was operating as expected. Regulated emission levels were very close to those posted by Cummins for this engine. Particulate matter with 2-D fuel was composed of about 53 percent soot and about 40 percent volatile organics(VOF). About half the organics were unburned lube oil, the rest being primarily unburned fuel. Sulfates and bound water made up only about 7 percent of the total particulate matter.

## TABLE 3. TRANSIENT EMISSIONS FROM A CUMMINS B5.9L ENGINE WITH RAPESEED BIODIESEL FUELS

| Test Number | Fuel | Catalyst | Transient Emissions (g/hp-hr) | | | | | BSFC, lb/hp-hr | Work, hp-hr |
|---|---|---|---|---|---|---|---|---|---|
| | | | HC | CO | NOx | $CO_2$ | PM | | |
| Cummins | Baseline | Yes | 0.21 | 1.30 | 4.05 | 577 | 0.079 | -- | -- |
| A-C1 | 2-D | No | 0.39 | 1.92 | 4.52 | 612 | 0.123 | 0.427 | 12.7 |
| A-H1 | 2-D | No | 0.28 | 1.40 | 4.33 | 601 | 0.104 | 0.418 | 12.6 |
| A-H2 | 2-D | No | 0.23 | 1.39 | 4.36 | 615 | 0.103 | 0.428 | 12.4 |
| **Composite** | **2-D** | **No** | **0.30** | **1.47** | **4.37** | **608** | **0.106** | **0.424** | **12.5** |
| AC-C1 | 2-D | Yes | 0.33 | 2.03 | 4.46 | 619 | 0.078 | 0.432 | 12.6 |
| AC-H1 | 2-D | Yes | 0.23 | 1.32 | 4.22 | 608 | 0.071 | 0.423 | 12.4 |
| AC-H2 | 2-D | Yes | 0.23 | 1.30 | 4.21 | 608 | 0.073 | 0.417 | 12.4 |
| **Composite** | **2-D** | **Yes** | **0.25** | **1.42** | **4.26** | **608** | **0.073** | **0.422** | **12.4** |
| A-C3 | 2-D | No | 0.36 | 2.02 | 4.61 | 644 | 0.120 | 0.449 | 12.3 |
| A-H4 | 2-D | No | 0.23 | 1.46 | 4.36 | 636 | 0.103 | 0.442 | 12.2 |
| A-H5 | 2-D | No | 0.30 | 1.48 | 4.38 | 632 | 0.106 | 0.440 | 12.2 |
| **Composite** | **2-D** | **No** | **0.30** | **1.55** | **4.40** | **635** | **0.107** | **0.442** | **12.2** |
| B-C1 | REE | No | 0.15 | 1.16 | 4.33 | 666 | 0.106 | 0.517 | 11.8 |
| B-H1 | REE | No | 0.11 | 0.86 | 4.25 | 643 | 0.008 | 0.499 | 11.8 |
| B-H2 | REE | No | 0.11 | 0.96 | 4.26 | 639 | 0.089 | 0.496 | 11.7 |
| **Composite** | **REE** | **No** | **0.11** | **0.95** | **4.26** | **645** | **0.091** | **0.500** | **11.7** |
| BC-C1 | REE | Yes | 0.19 | 0.89 | 4.33 | 670 | 0.055 | 0.520 | 11.7 |
| BC-H1 | REE | Yes | 0.06 | 0.59 | 4.25 | 649 | 0.045 | 0.503 | 11.7 |
| BC-H2 | REE | Yes | 0.07 | 0.61 | 4.26 | 647 | 0.046 | 0.501 | 11.8 |
| **Composite** | **REE** | **Yes** | **0.07** | **0.64** | **4.26** | **651** | **0.047** | **0.505** | **11.7** |
| B-C2 | REE | No | 0.19 | 1.41 | 4.44 | 663 | 0.113 | 0.516 | 11.4 |
| B-H3 | REE | No | 0.10 | 1.02 | 4.37 | 649 | 0.087 | 0.504 | 11.5 |
| B-H4 | REE | No | 0.10 | 1.00 | 4.45 | 648 | 0.090 | 0.503 | 11.4 |
| **Composite** | **REE** | **No** | **0.11** | **1.06** | **4.41** | **650** | **0.092** | **0.505** | **11.4** |
| C-C1 | RME | No | 0.12 | 1.17 | 4.59 | 655 | 0.096 | 0.509 | 11.8 |
| C-H1 | RME | No | 0.06 | 0.64 | 4.53 | 637 | 0.077 | 0.494 | 11.8 |
| C-H2 | RME | No | 0.06 | 0.86 | 4.50 | 643 | 0.078 | 0.499 | 11.8 |
| **Composite** | **RME** | **No** | **0.06** | **0.96** | **4.52** | **642** | **0.080** | **0.498** | **11.8** |
| CC-C1 | RME | Yes | 0.10 | 0.89 | 4.51 | 648 | 0.052 | 0.500 | 11.9 |
| CC-H1 | RME | Yes | 0.05 | 0.57 | 4.47 | 633 | 0.042 | 0.488 | 11.9 |
| CC-H2 | RME | Yes | 0.06 | 0.56 | 4.48 | 645 | 0.040 | 0.497 | 11.8 |
| **Composite** | **RME** | **Yes** | **0.06** | **0.61** | **4.48** | **640** | **0.042** | **0.494** | **11.8** |

## TABLE 3 (CONT'D). TRANSIENT EMISSIONS FROM A CUMMINS B5.9L ENGINE WITH RAPESEED BIODIESEL FUELS

| Test Number | Fuel | Catalyst | Transient Emissions (g/hp-hr) | | | | | BSFC, lb/hp-hr | Work, hp-hr |
|---|---|---|---|---|---|---|---|---|---|
| | | | HC | CO | NOx | $CO_2$ | PM | | |
| D-C1 | REE50 | No | 0.20 | 1.33 | 4.39 | 651 | 0.100 | 0.480 | 0.480 |
| D-H1 | REE50 | No | 0.16 | 0.98 | 4.20 | 619 | 0.091 | 0.456 | 0.456 |
| D-H2 | REE50 | No | 0.16 | 0.98 | 4.26 | 615 | 0.090 | 0.453 | 0.453 |
| **Composite** | **REE50** | **No** | **0.17** | **1.03** | **4.25** | **621** | **0.092** | **0.458** | **0.458** |
| DC-C1 | REE50 | Yes | 0.16 | 1.02 | 4.47 | 642 | 0.064 | 0.473 | 12.0 |
| DC-H1 | REE50 | Yes | 0.11 | 0.66 | 4.38 | 638 | 0.057 | 0.470 | 12.1 |
| DC-H2 | REE50 | Yes | 0.12 | 0.73 | 4.32 | 635 | 0.057 | 0.458 | 12.1 |
| **Composite** | **REE50** | **Yes** | 0.12 | **0.74** | **4.37** | **637** | **0.058** | **0.470** | **12.1** |
| E-C1 | RME50 | No | 0.19 | 1.20 | 4.46 | 630 | 0.094 | 0.463 | 12.3 |
| E-H1 | RME50 | No | 0.15 | 0.91 | 4.28 | 626 | 0.087 | 0.458 | 12.2 |
| E-H2 | RME50 | No | 0.15 | 0.96 | 4.27 | 623 | 0.085 | 0.458 | 12.2 |
| **Composite** | **RME50** | **No** | **0.16** | **0.97** | **4.30** | **625** | **0.087** | **0.458** | **12.2** |
| EC-C1 | RME50 | Yes | 0.14 | 0.97 | 4.44 | 637 | 0.059 | 0.468 | 12.2 |
| EC-H1 | RME50 | Yes | 0.11 | 0.64 | 4.29 | 623 | 0.055 | 0.458 | 12.2 |
| EC-H2 | RME50 | Yes | 0.11 | 0.67 | 4.27 | 619 | 0.054 | 0.454 | 12.2 |
| **Composite** | **RME50** | **Yes** | 0.11 | **0.70** | **4.30** | 623 | **0.055** | **0.458** | **12.2** |
| F-C1 | REE20 | No | 0.28 | 1.66 | 4.45 | 634 | 0.112 | 0.452 | 12.3 |
| F-H1 | REE20 | No | 0.22 | 1.17 | 4.27 | 619 | 0.097 | 0.441 | 12.2 |
| F-H2 | REE20 | No | 0.22 | 1.17 | 4.30 | 624 | 0.098 | 0.444 | 12.2 |
| **Composite** | **REE20** | **No** | **0.23** | **1.24** | **4.37** | **623** | **0.100** | **0.444** | **12.2** |
| FC-C1 | REE20 | Yes | 0.20 | 1.29 | 4.45 | 644 | 0.071 | 0.459 | 12.3 |
| EC-H1 | REE20 | Yes | 0.16 | 0.85 | 4.29 | 641 | 0.085 | 0.456 | 12.2 |
| EC-H2 | REE20 | Yes | 0.15 | 0.91 | 4.25 | 650 | 0.087 | 0.453 | 12.2 |
| **Composite** | **REE20** | **Yes** | **0.16** | **0.94** | **4.30** | **645** | **0.087** | **0.459** | **12.2** |
| G-C1 | RME20 | No | 0.25 | 1.43 | 4.57 | 626 | 0.101 | 0.450 | 12.3 |
| G-H1 | RME20 | No | 0.21 | 1.07 | 4.37 | 611 | 0.089 | 0.438 | 12.2 |
| G-H2 | RME20 | No | 0.21 | 1.11 | 4.35 | 623 | 0.095 | 0.447 | 12.2 |
| **Composite** | **RME20** | **No** | **0.22** | **1.14** | **4.39** | **618** | **0.093** | **0.444** | **12.2** |
| GC-C1 | RME20 | Yes | 0.18 | 1.29 | 4.45 | 626 | 0.073 | 0.450 | 12.3 |
| GC-H1 | RME20 | Yes | 0.14 | 0.89 | 4.35 | 613 | 0.062 | 0.439 | 12.2 |
| GC-H2 | RME20 | Yes | 0.15 | 0.94 | 4.28 | 616 | 0.063 | 0.442 | 12.2 |
| **Composite** | **RME20** | **Yes** | **0.15** | **0.97** | **4.33** | **616** | **0.064** | **0.442** | **12.2** |

# TABLE 4. COMPOSITION OF PARTICULATE EMISSIONS FROM A CUMMINS B5.9L ENGINE WITH RAPESEED BIODIESEL FUELS

| Test Number | Fuel | Catalyst | VOF - DFI/GC |  |  | SOF-Soxhlet |  | Sulfate |  | Soot,[a] g/hp-hr |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | % | g/hp-hr | %oil | % | g/hp-hr | % | g/hp-hr | w/DFI | w/SOF |
| A-C1 | 2-D | No | 36 | 0.045 | 57 | 57 | 0.07 | 2.7 | 0.003 | 0.070 | 0.04 |
| A-H1 | 2-D | No | 37 | 0.038 | 51 | 47 | 0.05 | 2.6 | 0.003 | 0.059 | 0.05 |
| B-H2 | 2-D | No | 38 | 0.040 | 52 | 47 | 0.05 | 2.6 | 0.003 | 0.059 | 0.05 |
| **Composite** | 2-D | No | 37 | 0.040 | 53 | 48 | 0.05 | 2.7 | 0.003 | 0.059 | 0.05 |
| A-C1 | 2-D | Yes | 32 | 0.025 | 47 | 36 | 0.03 | 1.1 | 0.001 | 0.051 | 0.05 |
| A-H1 | 2-D | Yes | 25 | 0.018 | 40 | 20 | 0.01 | 1.1 | 0.001 | 0.051 | 0.05 |
| A-H2 | 2-D | Yes | 32 | 0.024 | 50 | 35 | 0.03 | 0.9 | 0.001 | 0.047 | 0.05 |
| **Composite** | 2-D | Yes | 29 | 0.022 | 45 | 20 | 0.02 | 1.0 | 0.001 | 0.049 | 0.05 |
| A-C2 | 2-D | No | 37 | 0.045 | 62 | 48 | 0.06 | 2.5 | 0.003 | 0.068 | 0.05 |
| A-H3 | 2-D | No | 38 | 0.039 | 48 | 40 | 0.04 | 2.5 | 0.003 | 0.059 | 0.05 |
| A-H4 | 2-D | No | 38 | 0.042 | 60 | 47 | 0.05 | 2.5 | 0.003 | 0.057 | 0.05 |
| **Composite** | 2-D | No | 38 | 0.041 | 55 | 40 | 0.05 | 2.5 | 0.003 | 0.059 | 0.05 |
| B-C1 | REE | Yes | 72 | 0.076 | 60 | 53 | 0.06 | 0.3 | 0.000 | 0.029 | 0.05 |
| B-H1 | REE | Yes | 61 | 0.053 | 41 | 54 | 0.05 | 0.4 | 0.000 | 0.034 | 0.04 |
| B-H2 | REE | Yes | 64 | 0.057 | 48 | 64 | 0.06 | 0.2 | 0.000 | 0.032 | 0.03 |
| **Composite** | REE | Yes | 64 | 0.058 | 47 | 58 | 0.05 | 0.3 | 0.000 | 0.032 | 0.04 |
| B-C1 | REE | No | 42 | 0.023 | 44 | 57 | 0.03 | 0.4 | 0.000 | 0.031 | 0.02 |
| B-H1 | REE | No | 42 | 0.018 | 33 | 47 | 0.02 | 0.6 | 0.000 | 0.025 | 0.02 |
| B-H2 | REE | No | 48 | 0.022 | 39 | 58 | 0.03 | 0.5 | 0.000 | 0.023 | 0.02 |
| **Composite** | REE | No | 45 | 0.021 | 37 | 52 | 0.02 | 0.5 | 0.000 | 0.025 | 0.02 |
| B-C2 | REE | Yes | 63 | 0.071 | 48 | 75 | 0.08 | 0.2 | 0.000 | 0.041 | 0.03 |
| B-H3 | REE | Yes | 62 | 0.054 | 39 | 82 | 0.07 | 0.3 | 0.000 | 0.032 | 0.02 |
| B-H1 | REE | Yes | 68 | 0.061 | 47 | 71 | 0.06 | 0.3 | 0.000 | 0.028 | 0.03 |
| **Composite** | REE | Yes | 65 | 0.069 | 43 | 76 | 0.07 | 0.3 | 0.000 | 0.032 | 0.02 |
| C-C1 | RME | No | 23 | 0.022 | 45 | 70 | 0.07 | 0.3 | 0.000 | 0.073 | 0.03 |
| C-H1 | RME | No | 63 | 0.049 | 37 | 76 | 0.06 | 0.3 | 0.000 | 0.027 | 0.02 |
| C-H2 | RME | No | 25 | 0.078 | 40 | 74 | 0.06 | 0.3 | 0.000 | 0.000 | 0.02 |
| **Composite** | RME | No | 41 | 0.058 | 39 | 74 | 0.06 | 0.3 | 0.000 | 0.022 | 0.02 |
| C-C1 | RME | Yes | 102 | 0.053 | 52 | 61 | 0.03 | 0.4 | 0.000 | 0.000 | 0.02 |
| C-H1 | RME | Yes | 53 | 0.022 | 41 | 65 | 0.03 | 0.6 | 0.000 | 0.018 | 0.01 |
| C-H2 | RME | Yes | 115 | 0.036 | 52 | 82 | 0.02 | 0.5 | 0.000 | 0.000 | 0.01 |
| **Composite** | RME | Yes | 87 | 0.037 | 47 | 63 | 0.03 | 0.5 | 0.000 | 0.005 | 0.02 |

[a] Soot w/DFI is calculated using VOF by DFI-GC and w/SOF is calculated using SOF by Soxhlet extraction.

## TABLE 4 (CONT'D). COMPOSITION OF PARTICULATE EMISSIONS FROM A CUMMINS B5.9L ENGINE WITH RAPESEED BIODIESEL FUELS

| Test Number | Fuel | Catalyst | VOF - DFI/GC | | | SOF-Soxhlet | | Sulfate | | Soot,[a] g/hp-hr | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | % | g/hp-hr | %oil | % | g/hp-hr | % | g/hp-hr | w/DFI | w/SOF |
| D-C2 | REE50 | No | 26 | 0.026 | 41 | 65 | 0.07 | 1.6 | 0.002 | 0.070 | 0.03 |
| D-H1 | REE50 | No | 46 | 0.042 | 46 | 61 | 0.06 | **1.6** | 0.001 | 0.040 | 0.03 |
| D-H2 | REE50 | No | 31 | 0.028 | 41 | 62 | 0.06 | 1.5 | 0.001 | 0.059 | **0.03** |
| **Composite** | **REE50** | **No** | **37** | **0.034** | 43 | 62 | **0.06** | **1.6** | **0.001** | **0.055** | **0.03** |
| DC-C1 | REE50 | Yes | 100 | 0.064 | 50 | 41 | 0.03 | 1.1 | 0.001 | 0.000 | 0.04 |
| DC-H1 | REE50 | Yes | 34 | 0.019 | 43 | 37 | 0.02 | 1.1 | 0.001 | 0.036 | 0.03 |
| DC-H2 | REE50 | Yes | 51 | 0.020 | 47 | 42 | 0.02 | 1.2 | 0.001 | 0.026 | 0.03 |
| **Composite** | **REE50** | **Yes** | 51 | **0.030** | 46 | **46** | **0.02** | 1.1 | **0.001** | **0.027** | **0.03** |
| E-C1 | RME50 | No | 53 | 0.049 | 57 | 62 | 0.06 | 1.6 | 0.002 | 0.041 | 0.03 |
| F-H1 | RME50 | No | **54** | 0.047 | 60 | 63 | 0.05 | 1.6 | 0.001 | 0.037 | 0.03 |
| F-H2 | RME50 | No | 55 | 0.047 | **53** | 66 | 0.06 | **1.6** | 0.001 | 0.036 | 0.03 |
| **Composite** | **RME50** | **No** | **54** | **0.047** | **57** | **64** | **0.06** | **1.6** | **0.001** | **0.036** | **0.03** |
| EC-C1 | RME50 | Yes | 38 | 0.023 | 44 | 52 | 0.03 | 1.9 | 0.001 | 0.033 | 0.03 |
| EC-H1 | RME50 | Yes | 43 | 0.024 | 50 | 45 | 0.02 | 1.5 | 0.001 | 0.029 | 0.03 |
| FC-H2 | RME50 | Yes | 37 | 0.020 | 45 | **46** | 0.02 | 1.6 | 0.001 | 0.032 | 0.03 |
| **Composite** | **RME50** | **Yes** | 40 | **0.022** | 47 | **46** | **0.03** | **1.7** | **0.001** | **0.031** | **0.03** |
| F-C1 | REE20 | No | 33 | 0.037 | 63 | 65 | 0.07 | 2.2 | 0.002 | 0.069 | 0.03 |
| F-H1 | REE20 | No | 48 | 0.046 | 60 | 58 | 0.06 | 1.9 | 0.002 | 0.046 | 0.04 |
| F-H2 | REE20 | No | 45 | 0.044 | 54 | 60 | 0.06 | 2.2 | 0.002 | 0.049 | 0.03 |
| **Composite** | **REE20** | **No** | 45 | **0.044** | **58** | **60** | **0.06** | **2.1** | **0.002** | **0.051** | **0.03** |
| EC-C1 | REE20 | Yes | 29 | 0.021 | 49 | 48 | 0.03 | 1.6 | 0.001 | 0.047 | 0.03 |
| FC-H1 | REE20 | Yes | 29 | 0.019 | 52 | 37 | 0.02 | 1.6 | 0.001 | 0.043 | 0.04 |
| FC-H2 | REE20 | Yes | 29 | 0.019 | 44 | 35 | 0.02 | **1.7** | 0.001 | 0.040 | 0.04 |
| **Composite** | **REE20** | **Yes** | 29 | **0.019** | **48** | **38** | **0.03** | 1.6 | **0.001** | **0.040** | **0.04** |
| G-C1 | RME20 | No | 47 | 0.048 | 59 | 61 | 0.06 | 2.3 | 0.002 | 0.047 | 0.03 |
| G-H1 | RME20 | No | 44 | 0.039 | 47 | 58 | **0.05** | 2.7 | 0.002 | 0.044 | 0.03 |
| G-H2 | RME20 | **No** | 44 | 0.041 | 58 | 66 | 0.06 | 2.5 | 0.002 | 0.048 | 0.03 |
| **Composite** | **RME20** | No | 44 | **0.041** | **53** | **58** | **0.05** | **2.6** | **0.002** | **0.048** | **0.03** |
| GC-C1 | RME20 | Yes | 15 | 0.011 | 51 | 29 | 0.02 | 1.4 | 0.001 | 0.059 | 0.05 |
| GC-H1 | RME20 | Yes | 33 | 0.020 | 37 | 34 | 0.02 | 1.5 | 0.001 | 0.040 | 0.04 |
| GC-H2 | RME20 | Yes | 30 | 0.019 | 43 | 31 | 0.02 | 1.4 | 0.001 | 0.042 | 0.04 |
| **Composite** | **RME20** | **Yes** | **29** | **0.018** | **42** | **32** | **0.02** | **1.4** | **0.001** | **0.043** | **0.04** |

[a] Soot w/DFI is calculated using VOF by DFI-GC and w/SOF is calculated using SOF by Soxhlet extraction.

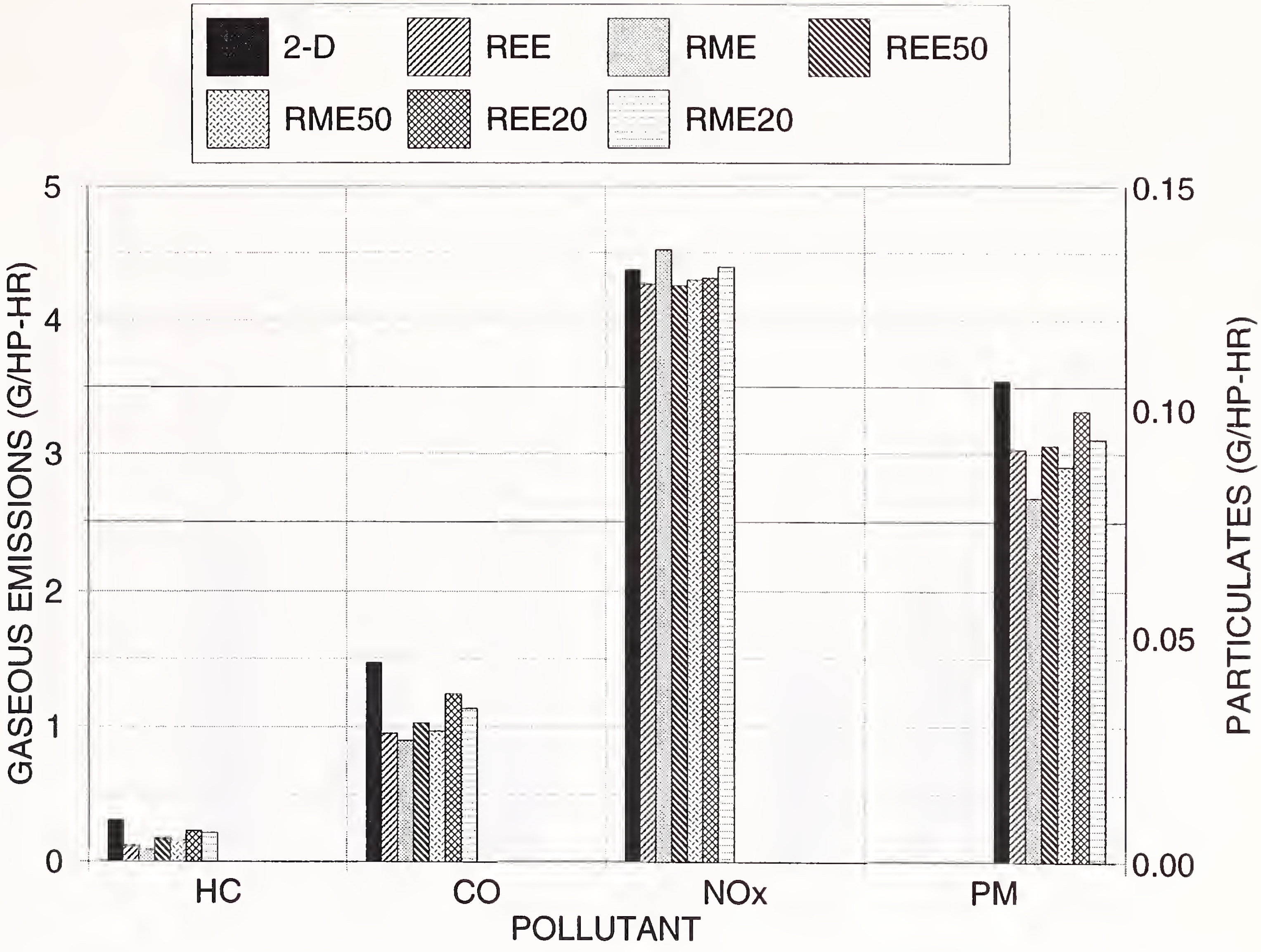

FIGURE 4. COMPOSITE TRANSIENT REGULATED EMISSION LEVELS WITHOUT CATALYST

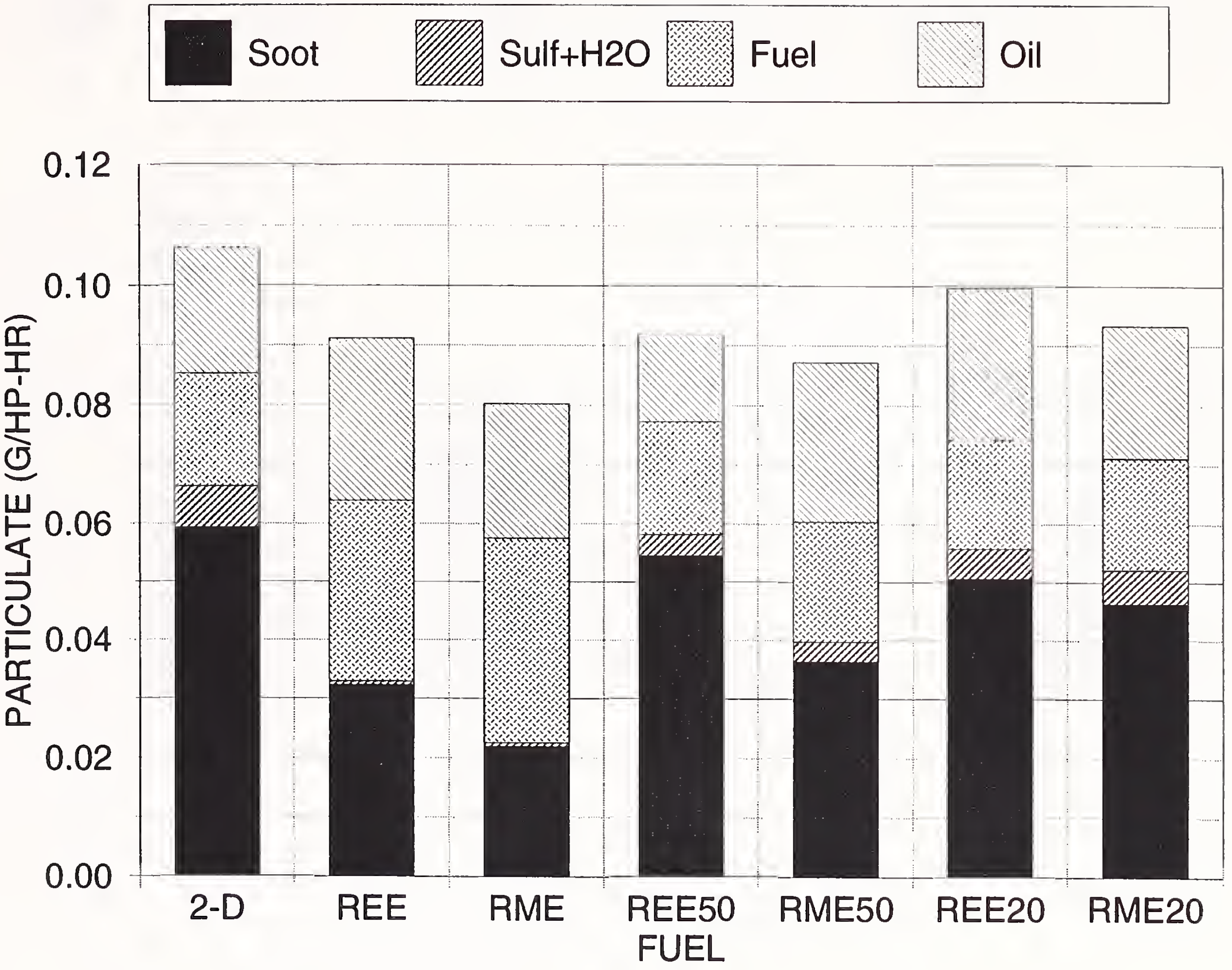

FIGURE 5. COMPOSITION OF TRANSIENT PARTICULATE EMISSIONS WITHOUT CATALYST

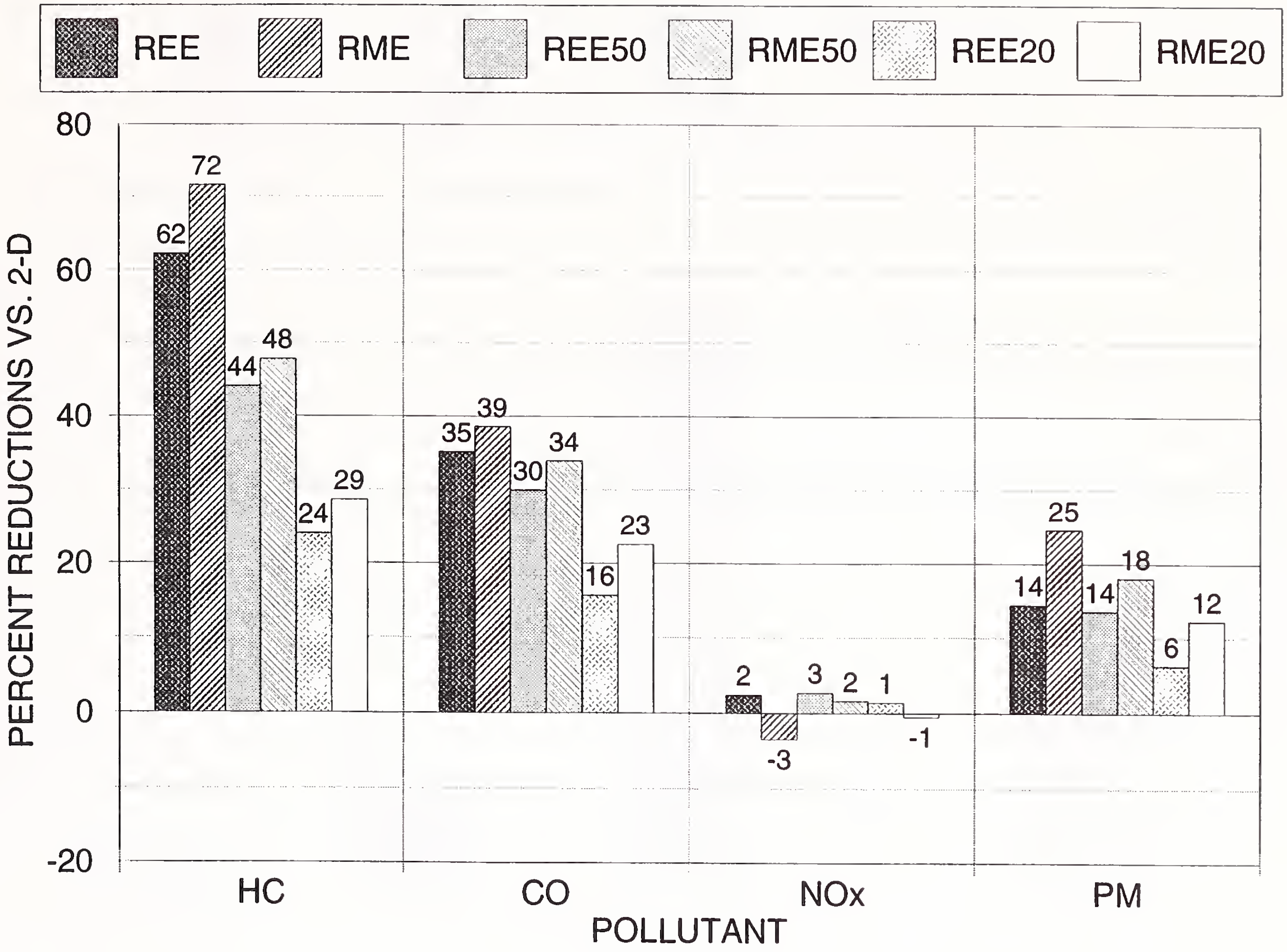

FIGURE 6. PERCENT CHANGE IN COMPOSITE EMISSION LEVELS WITHOUT CATALYST, BIODIESEL FUELS VERSUS DIESEL

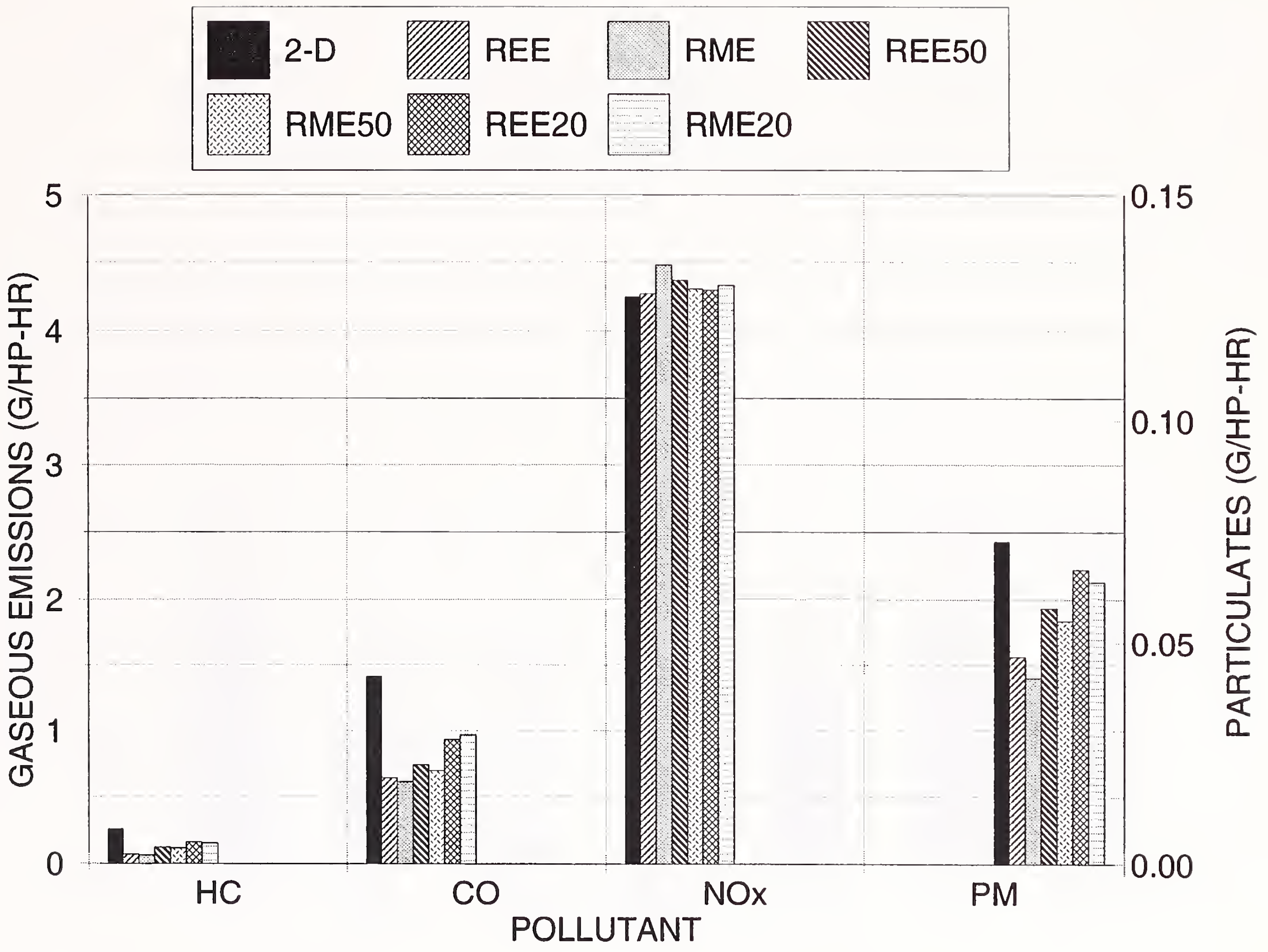

FIGURE 7. COMPOSITE TRANSIENT REGULATED EMISSION LEVELS WITH CATALYST

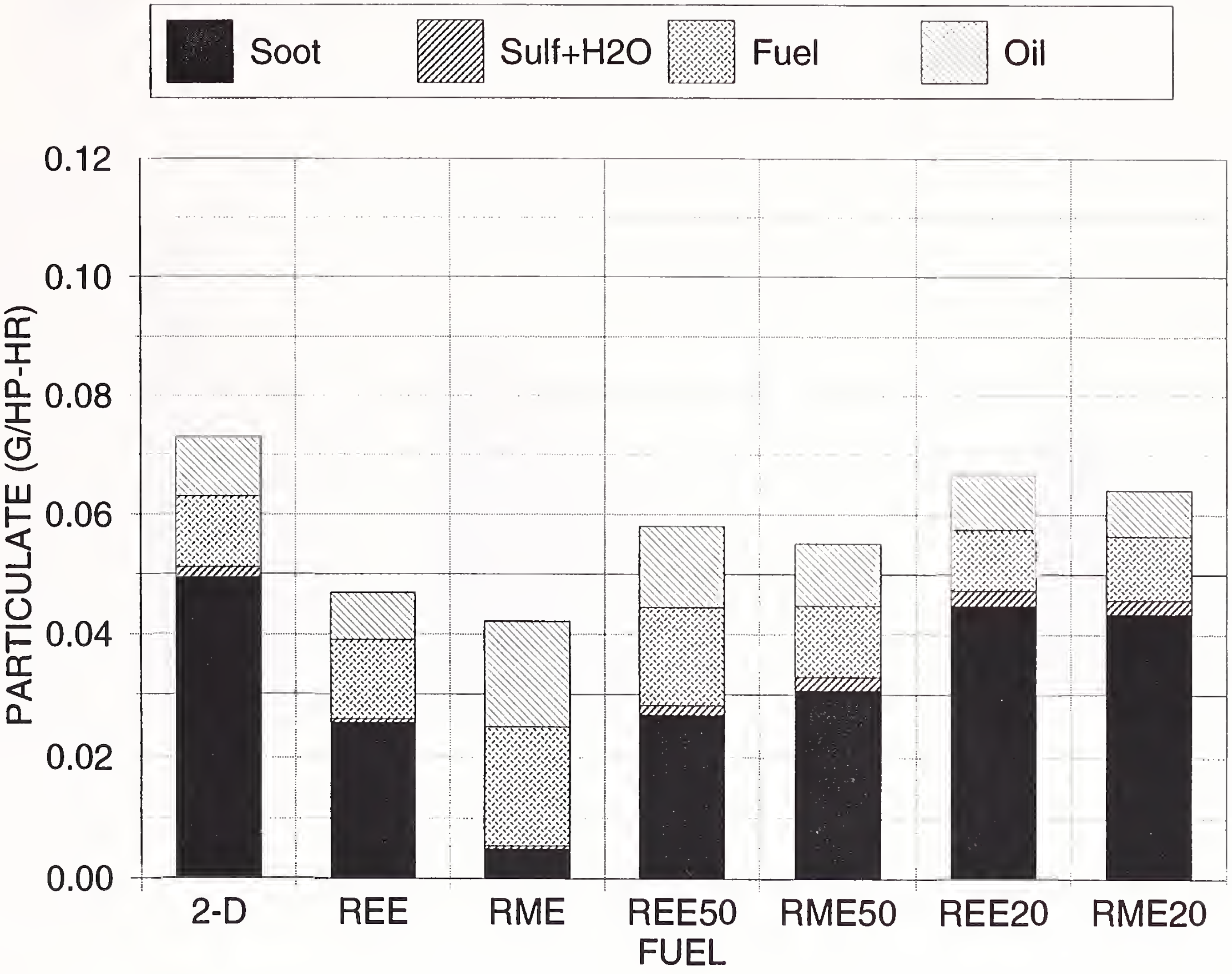

FIGURE 8. COMPOSITION OF TRANSIENT PARTICULATES WITH CATALYST

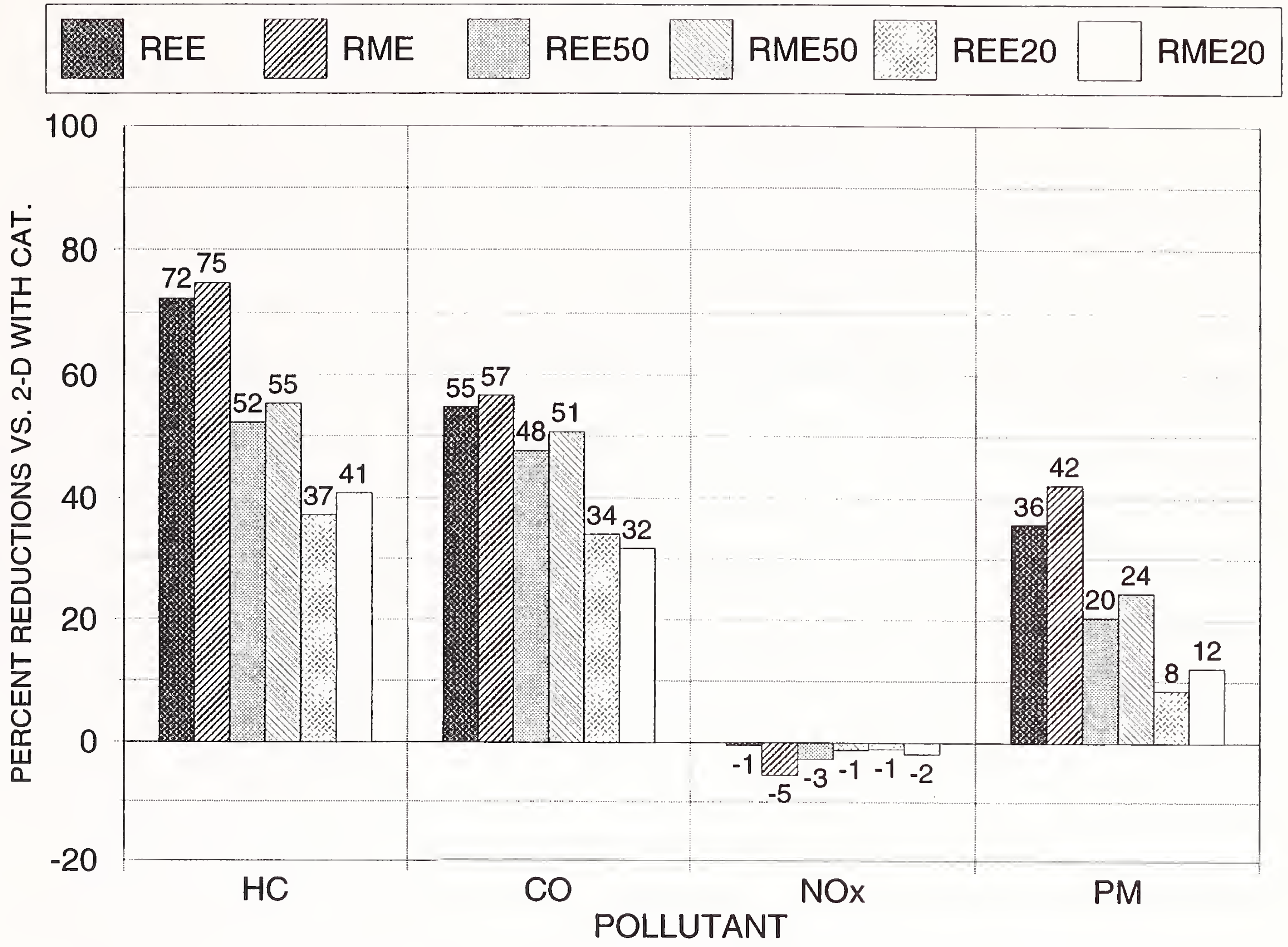

FIGURE 9. PERCENT CHANGE IN REGULATED EMISSION LEVELS WITH CATALYST, BIODIESEL FUELS VERSUS DIESEL

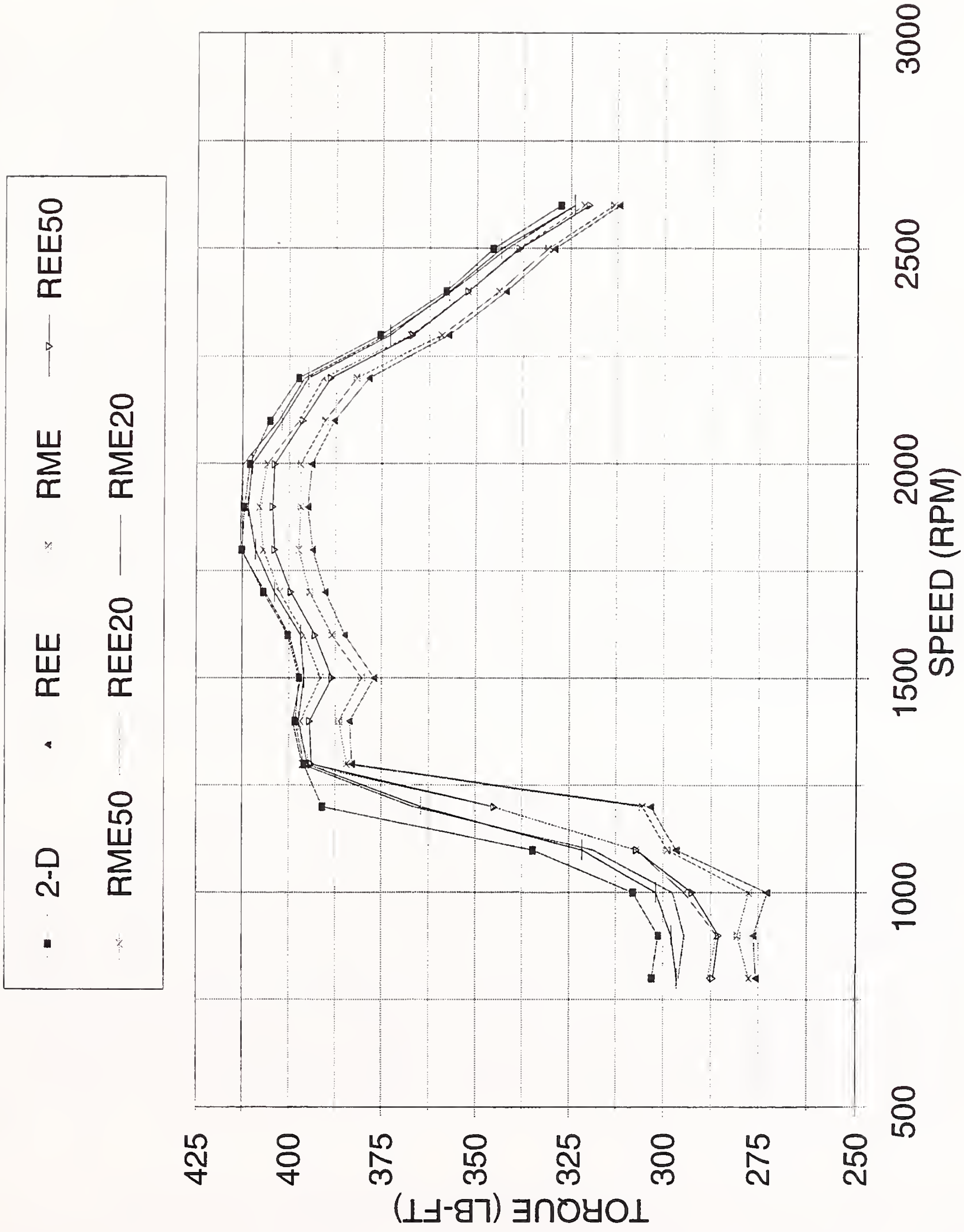

FIGURE 10. AVERAGE TRANSIENT TORQUE-MAP DATA FOR CUMMINS B5.9L ENGINE WITH BIODIESEL FUELS

A repeat test day was run with 2-D fuel to address the question of day-to-day repeatability. Both the regulated emissions and the particulate composition were repeated, generally within one percent, except for CO and BSFC which had slightly higher variation.

When the catalyst was installed, no changes in engine performance or fuel economy were observed. With the catalyst, which is the typical configuration for this engine, the composite regulated emissions of the engine on 2-D fuel were well within the 1995 emissions standards for on-road heavy-duty diesel engines. The catalyst reduced hydrocarbon emissions by 16 percent, and reduced total particulate emissions by 31 percent. The catalyst had no effect on $NO_x$ emissions, as expected, but it was also ineffective in reducing CO.

Particulate composition results, given in Figure 8, indicate that the catalyst was very effective in reducing the unburned fuel and oil portions of the particulate by about 50 percent each, but that it had essentially no effect on the other constituents of the particulate matter. The low HC oxidation efficiency of the catalyst, compared to reasonable particulate oxidation, indicated that this catalyst was very effective in oxidizing heavier hydrocarbons, but not very efficient at oxidizing light hydrocarbons. This observation was confirmed by the hydrocarbon speciation data, as discussed later, and it was later learned that this particular oxidation catalyst was primarily designed to control particulate emissions by oxidizing heavier organic hydrocarbons, such as unburned diesel fuel and oil. The catalyst was not very effective on CO and lighter hydrocarbon emissions.

### 2. Neat Biodiesel Fuels

Both neat biodiesel fuels, REE and RME, had a significant effect on engine performance and brake specific fuel consumption (BSFC). Both neat biodiesel fuels resulted in a loss of performance, as reflected by an average of 6 percent less torque over the transient torque-map, as well as a reduction in work done during the transient cycle. BSFC was also poorer with REE and RME. Transient cycle BSFC increased as much as 18 percent over 2-D fuel. These results are consistent with the lower energy content of biodiesel relative to diesel fuel, although the increase in BSFC was larger than expected based on energy content alone. RME had a slightly smaller performance and BSFC penalty than REE.

As shown in Figure 6, compared to 2-D fuel, HC emissions were 62 and 72 percent lower for REE and RME, respectively. Lower HC emissions are probably due in part to the oxygen in the biodiesel fuel, but also due to the fact that unburned biodiesel is composed of heavy ($C_{18}$ to $C_{20}$) compounds with high boiling points, and contains no light- and middle-distillate hydrocarbon components as

diesel fuel does. Therefore unburned biodiesel will likely condense to form particulate matter. CO emissions were roughly 40 percent lower with both neat biodiesel fuels, probably a result of the high oxygen content of neat biodiesel. Compared to 2-D, $NO_x$ did not show any significant change with REE, while RME appeared to cause a slight increase in $NO_x$. Particulate emissions using REE and RME were 14 and 25 percent lower than obtained on 2-D fuel.

Examination of the particulate composition data in Figure 5 shows that soot decreased 50 percent or more for both REE and RME, likely as a result of the fuels' high oxygen content. Particulate from RME had slightly lower soot levels than REE. However, the volatile organic fraction of particulates derived from unburned fuel was roughly 50 percent higher with neat biodiesel than with 2-D fuel because unburned biodiesel fuel tends to be measured as particulate matter, rather than as gaseous hydrocarbons. The sulfate portion of the total particulate was essentially eliminated with neat biodiesel because biodiesel contains no sulfur, although this had a very small impact on total particulate emission levels.

Comparing results shown in Figure 6 and Figure 9, the percent differences in HC, CO, and particulate with the neat biodiesel fuels compared to diesel fuel were larger with the catalyst than without the catalyst. Another way to examine this is to look at the conversion efficiency of the catalyst for both biodiesel and diesel fuel. Figure 11 shows the conversion efficiency of the catalyst on each of the regulated pollutants for all seven fuels. For both REE and RME, the conversion efficiency of the catalyst was higher on HC, CO, and particulate than it is for 2-D fuel. This means that biodiesel produced less of these pollutants in the engine exhaust, and also enhanced the ability of the catalyst to reduce the engine-out emissions.

In the case of particulates, the improved conversion efficiency of the catalyst with biodiesel fuel can perhaps be explained by the fact that volatile organic compounds made up a much larger fraction of the total particulates with neat biodiesel fuel than with diesel fuel. Because this catalyst was most effective on this portion of particulates, it would tend to be more efficient in reducing particulates from a biodiesel-fueled engine. The data shown in Figure 8 indicate that the catalyst had no difficulty in dealing with the increased volatile organics emitted from the biodiesel fueled engine, and the soot levels were also reduced due to the oxygen in the biodiesel. For HC and CO emissions, the increased catalyst efficiency is difficult to explain. A more detailed study would be required to determine the exact mechanism at work.

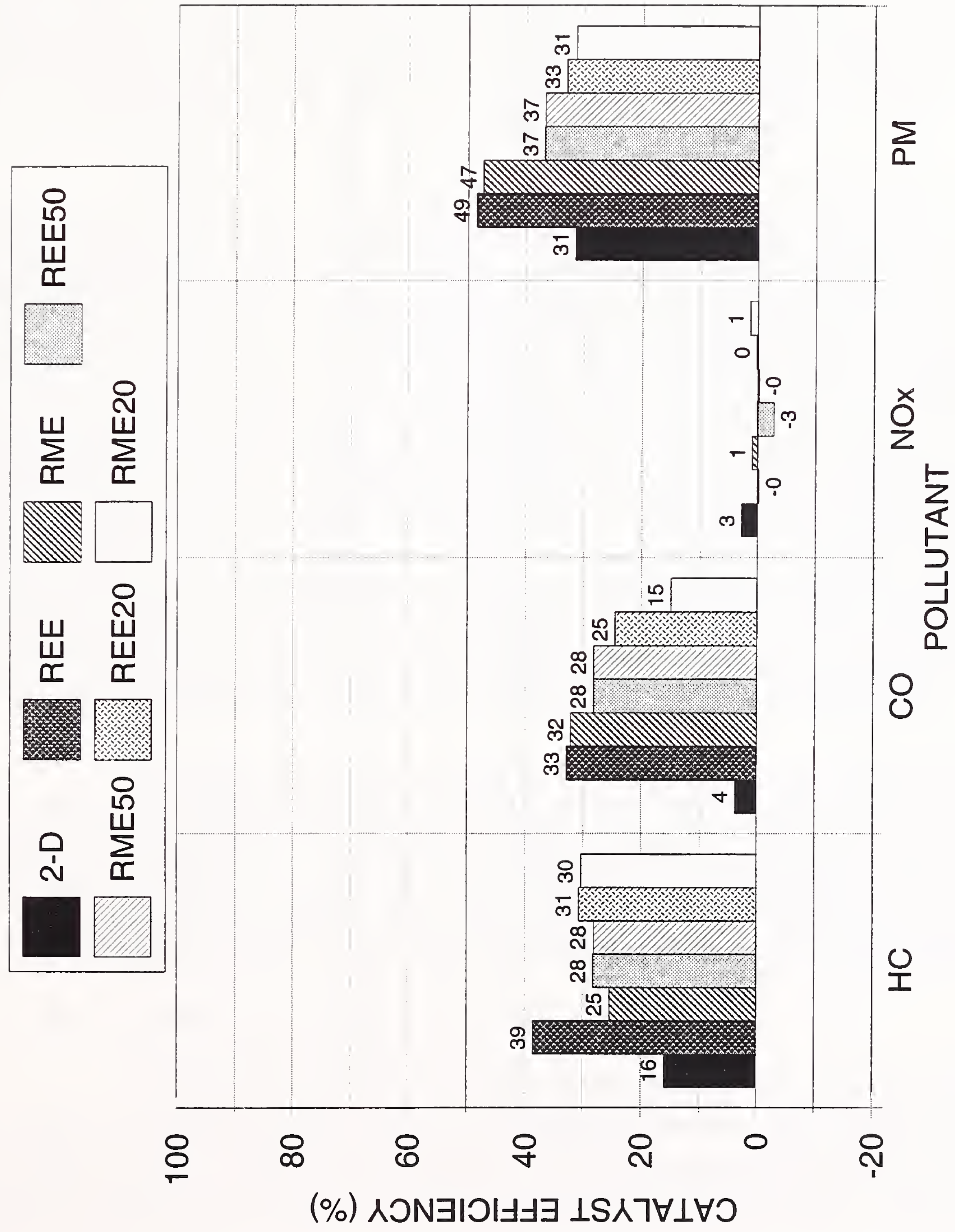

FIGURE 11. CATALYST CONVERSION EFFICIENCY FOR REGULATED POLLUTANTS WITH BIODIESEL FUELS

### 3. 50 Percent Biodiesel Blends

The two 50 percent diesel and biodiesel blends, REE50 and RME50, did not have nearly the same adverse impact on performance and BSFC as the neat biodiesel fuels. There was still a loss in torque of about 3 percent over the torque-map, and a similar loss of work over the transient cycle. Transient cycle BSFC was about 8 percent higher on the 50 percent blends compared to diesel fuel. This reflects the fact that the 50 percent blends fall about halfway between the neat biodiesels and diesel fuel in terms of energy content.

In terms of regulated emissions, the levels observed for CO and particulates with the 50 percent biodiesel blends were nearly the same as for the neat biodiesel fuel. Decreases from 2-D fuel hydrocarbon levels with REE50 and RME50 were smaller than with REE and RME, but they were still about 50 percent lower. As before, the methyl ester blend (RME50) achieved slightly lower levels of HC, CO, and particulate than the ethyl ester blend (REE50). $NO_x$ emission levels observed with diesel fuel were unchanged with the 50 percent blends. Particulate composition data with REE50 and RME50 showed that carbon soot was reduced compared to 2-D fuel, but unburned fuel-derived VOF increased, although not quite as much as was the case for REE and RME. This indicated that the trends in particulate composition observed with neat biodiesel were similar with the 50 percent blends, but to a slightly lower degree. This reflects the fact that there tends to be less unburned biodiesel with the 50 percent blends, as compared to the neat biodiesel, but also about half as much oxygen in the blends as in the neat biodiesel fuels. Sulfate levels were about half the level observed for diesel fuel.

Catalyst oxidation efficiency for HC and CO with the 50 percent blends was significantly better than with diesel fuel, and nearly as good as it had been for the neat biodiesel fuels. However, particulate conversion efficiency was lower with REE50 and RME50 than with REE and RME. This lower catalyst efficiency with the 50 percent blends reflects the smaller fraction of particulates made up of VOF with the 50 percent blends than when the neat biodiesel fuels were tested.

### 4. 20 Percent Biodiesel Blends

The 20 percent blends, REE20 and RME20, had no appreciable effect on engine performance, and only a small effect on BSFC. Torque levels with the 20 percent blends were nearly identical to those obtained with 2-D fuel, as was transient cycle work. BSFC with the 20 percent blends was about 5 percent worse than for diesel fuel.

Regulated emission data indicated that significant reductions in HC and CO emissions were evident with REE20 and RME20, as compared to 2-D fuel. However, particulates were only about 10 percent lower. $NO_x$ emissions remained

unchanged. Particulate composition data for the 20 percent blends indicated lower levels of soot and increased VOF, compared to 2-D fuel, but these variations were fairly small, and sulfates were nearly identical to the levels observed for diesel fuel. With the 20 percent blends the trends in particulate composition are consistent with those for the higher biodiesel content fuels, but the levels of change were much smaller. As had been observed for the neat biodiesel and the 50 percent blends, the methyl ester appeared to reduce HC, CO, and particulate emissions slightly better than the ethyl ester.

Catalyst efficiency in reducing HC and CO emissions remained significantly higher with REE20 and RME20 than for 2-D fuel. Apparently the mechanism of enhanced conversion of HC and CO depends more on the presence of some threshold quantity of biodiesel, rather than on the gross amount of biodiesel present. Particulate conversion efficiency was identical to that observed for 2-D fuel, and reflects similar particulate compositions for the 20 percent blends and the diesel fuel.

## B. Hydrocarbon Speciation

### 1. $C_1$ - $C_{12}$ Speciation

Speciation data for hydrocarbons in the $C_1$ - $C_{12}$ range is given in Appendix B. These data are also shown graphically in Appendix C, which summarizes the composite data for each fuel by carbon number and general class of compounds, both in terms of mass and ozone formation potential.

The $C_1$ - $C_{12}$ speciation data for 2-D fuel indicated that about 50 percent of the total composite HC emissions fell into this carbon range. Of this total, about 35 percent were composed of aldehydes, with another 40 percent being olefins which were essentially combustion products like ethylene and propylene. The remaining 25 percent were broken down evenly between paraffins and aromatics, with a small amount of other unidentified $C_9$ and higher hydrocarbons. These probably represent the broken apart pieces of larger fuel molecules, and the small portion of unburned fuel components that are in the $C_{10}$ and higher carbon number range.

When the catalyst was installed with 2-D fuel, the mass of total HC decreased by about 15 percent. However, the mass of speciated hydrocarbons in the $C_1$ - $C_{12}$ range actually increased. Figures 12 and 13 show a comparison of the seven test fuels both with and without catalyst, in terms of the total speciated

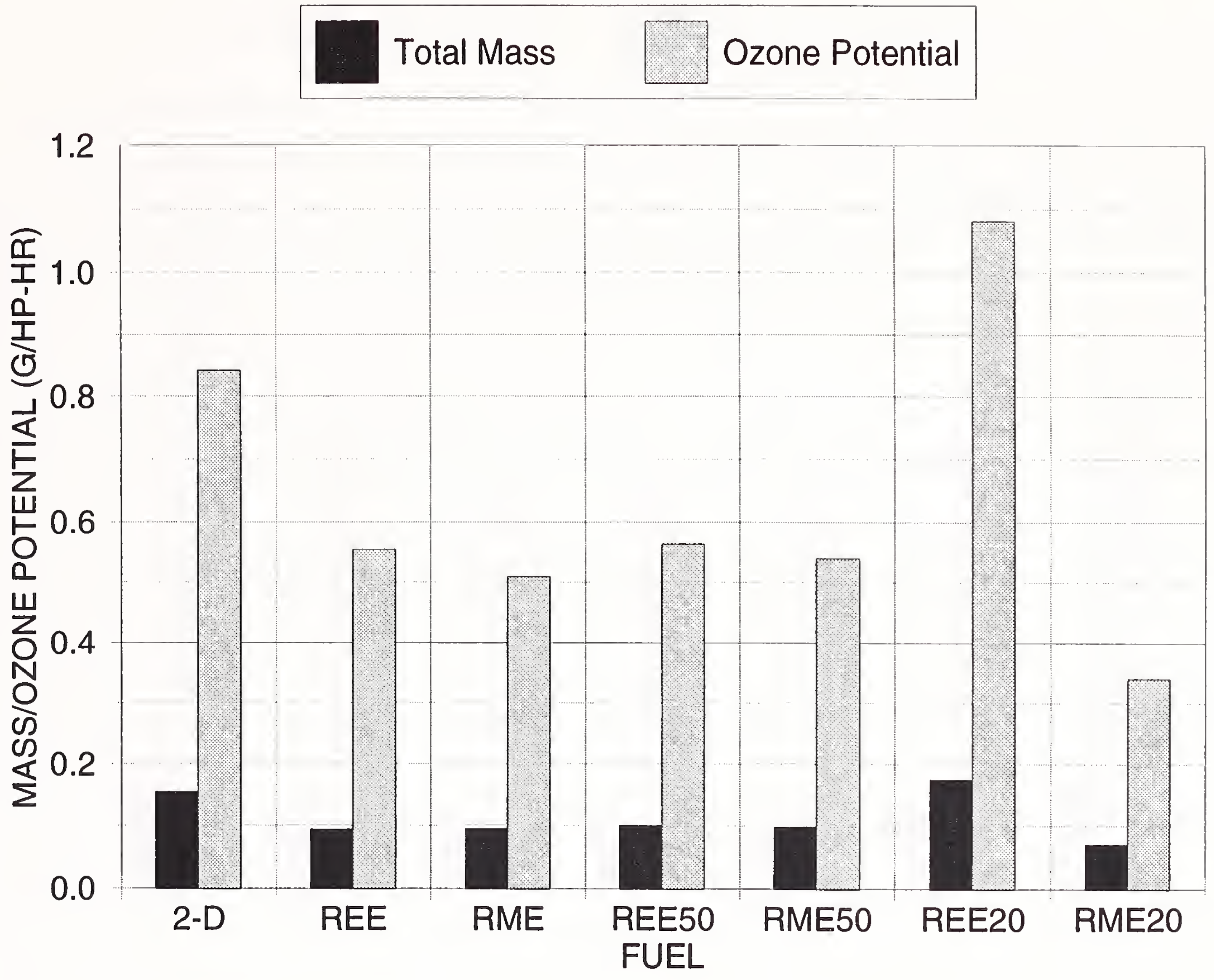

FIGURE 12. C1 - C12 HYDROCARBON MASS AND REACTIVITY WITHOUT CATALYST

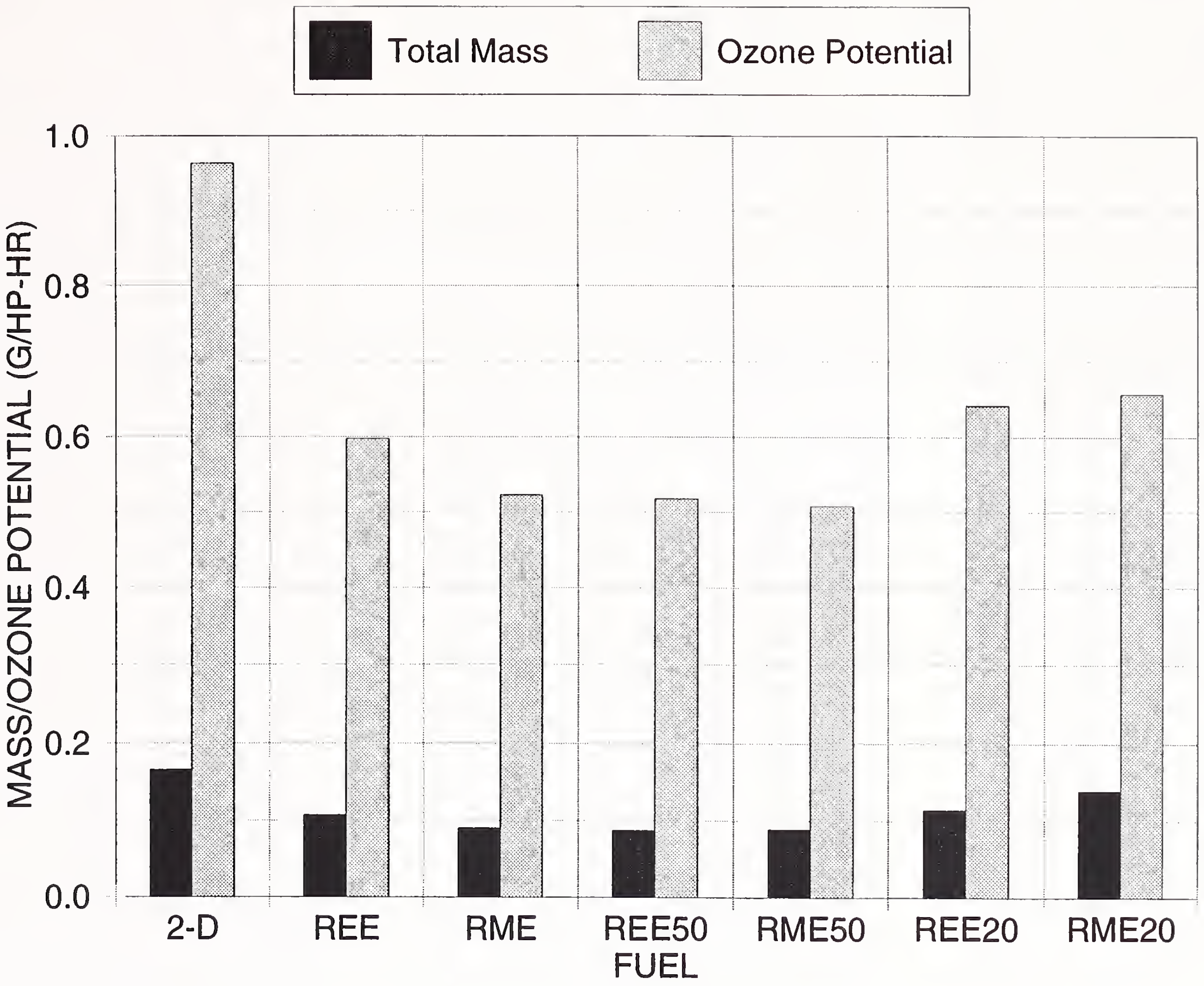

FIGURE 13. C1 - C12 HYDROCARBON MASS AND REACTIVITY WITH CATALYST

hydrocarbon mass in the $C_1$ - $C_{12}$ range, and also in terms of the total ozone potential of those hydrocarbon emissions. The catalyst actually caused a 7 percent increase in the total speciated mass, and about a 15 percent increase in ozone potential, indicating the formation of more reactive species. The composition of the speciated mass shifted toward less paraffin and aromatics but more aldehydes. This indicates that this catalyst was optimized to deal with heavier unburned diesel fuel components and unburned lube oil which tend to form particulates. When dealing with the lighter combustion products and fuel components, this catalyst was only able to partially oxidize them, thus leaving behind some more reactive species than were in the engine-out exhaust. It may also indicate that some aldehydes may have formed in the catalyst due to the partial oxidation of heavier hydrocarbons. This can be seen in the higher masses of formaldehyde and acetaldehyde for 2-D fuel with the catalyst, as compared to 2-D fuel without the catalyst.

REE and RME, the neat biodiesel fuels, had a significant or noticeable effect on the speciated HC emissions, both in terms of quantity and composition. The sum of $C_1$ - $C_{12}$ components accounted for nearly all of the total HC mass, indicating that very few gaseous HC species above $C_{12}$ were present in the exhaust with REE and RME. There were also a significantly smaller number of species present, as can be seen from the graphs in Appendix C. Aldehydes and light olefins accounted for nearly 90 percent of the mass present, with the paraffins and aromatics making up only a small portion of the total mass. The overall reduction in speciated HC mass was about 40 percent for both neat biodiesel fuels, which was accompanied by a similar reduction in ozone potential. As had been the case for 2-D fuel, the catalyst was not effective in dealing with the $C_1$ - $C_{12}$ hydrocarbons. With REE the catalyst tended to increase both the mass and reactivity of the $C_1$ - $C_{12}$ hydrocarbons, while with RME no change was apparent.

The 50 percent blends, REE50 and RME50, were similar to the neat biodiesel fuels, in terms of $C_1$ - $C_{12}$ hydrocarbons. This was true in terms of both mass and composition of the species present. The speciated mass for both REE50 and RME50 was about 40 percent lower than for 2-D fuel, as was the ozone potential. With REE50 and RME50, the $C_1$ - $C_{12}$ hydrocarbons made up about 60 percent of the total HC emissions, which indicates the presence of heavier unburned fuel components, most likely due to the diesel fuel present in the blends. A few more aromatics and paraffins were present with REE50 and RME50 than for REE and RME, which also reflect the presence of the diesel fuel in the blends. However, these components were present only in very small amounts and had little effect on either total mass or reactivity. The catalyst did not appear to have any significant effect on either the mass or reactivity of the $C_1$ - $C_{12}$ hydrocarbons for the 50 percent blends.

The 20 percent blends, REE20 and RME20, did not give expected emission results as established from the other biodiesel fuels. In the case of REE20, the mass of $C_1$ - $C_{12}$ hydrocarbons actually increased 13 percent compared to 2-D fuel, and was also more reactive with a 30 percent increase in ozone potential. This increase was primarily the result of a large increase in formaldehyde emissions, about twice the level measured for 2-D fuel, as well as a significant increase in several heavier aldehydes. RME20, on the other hand, appeared to have the lowest mass of $C_1$ - $C_{12}$ hydrocarbons of all of the fuels, as well as the lowest ozone potential. The composition of the $C_1$ - $C_{12}$ hydrocarbons with RME20 was similar to that determined for RME50 (50 percent RME). However, the mass of the species present was lower, except in the case of the aldehydes which were essentially the same for both RME50 and RME20. The total speciated mass for RME20 was about 55 percent lower, and the ozone potential was about 60 percent lower than that determined for 2-D fuel. This inconsistency in the results for REE20 and RME20 indicated the possibility of measurement error, but no error could be found in a review of the results. The reason for the unusual behavior of REE20 as compared to RME20 is not known at this time.

With the catalyst installed, REE20 and RME20 behaved in a similar manner. As would be expected, the results fell in between the tests with 2-D fuel (diesel fuel) and REE50 and RME50 (50 percent blends). This was true in terms of both speciated mass and ozone potential. The composition of $C_1$ - $C_{12}$ hydrocarbons was very similar to that observed for 2-D fuel with a catalyst. Considering the fact that this catalyst does not appear effective in reducing lighter HC emissions, this result would seem to indicate that the engine out emissions were also at expected levels, which is not consistent with what the previous measurements had indicated. These results imply that the data for REE20 without catalyst may have been outliers.

### 2. $C_{13}$ - $C_{22}$ Speciation

The heavier hydrocarbons in the $C_{13}$ - $C_{22}$ range were not examined in the same manner as most of the other emissions data because the data from the GC/MS were *qualitative* rather than quantitative. However, differences between the fuels were evident on this basis, especially in the case of the neat biodiesel fuels, REE and RME.

In addition to the analysis of exhaust emissions from the various fuels, neat samples of REE and RME were diluted in laboratory reagent grade n-hexane, and subjected to GC/MS analysis. The composition of these fuels is detailed in Table 5 below.

## TABLE 5. MAJOR CONSTITUENTS OF RME AND REE FUELS

| RAPESEED METHYL ESTER | | RAPESEED ETHYL ESTER | |
|---|---|---|---|
| COMPOUND | AREA PERCENT† | COMPOUND | AREA PERCENT† |
| 7,10,13-hexadecatrienoic acid, methyl ester | 0.14 | dodecanoic acid ethyl ester | 0.03 |
| 9-hexadecenoic acid, methyl ester | 0.19 | tetradecanoic acid, ethyl ester | 0.04 |
| hexadecanoic acid, methyl ester | 5.96 | 9-hexadecenoic acid, ethyl ester | 0.16 |
| heptadecanoic acid, methyl ester | 0.09 | hexadecanoic acid, ethyl ester | 0.04 |
| 9,12-octadecadienoic acid, methyl ester | 16.87 | 9-octadecenoic acid, methyl ester, (Z) | 0.06 |
| 9-octadecenoic acid, methyl ester | 22.44 | 9-octadecenoic acid, ethyl ester, (Z) | 30.70 |
| octadecanoic acid, methyl ester | 2.54 | octadecanoic acid, ethyl ester | 2.10 |
| 11-eicosenoic acid, methyl ester | 16.39 | 1,4-cyclooctadiene | 0.07 |
| eicosanoic acid, methyl ester | 1.33 | 11,14 Eicosadienoic acid, methyl ester | 14.76 |
| 13-docosenoic acid, methyl ester | 32.11 | eicosanoic acid, ethyl ester | 1.47 |
| docosanoic acid, methyl ester | 0.84 | 13-docosenoic acid, methyl ester, (Z) | 39.23 |
| 15-tetracosenoic acid, methyl ester | 0.54 | octadecanoic acid, ethyl ester | 1.39 |
| tetracosanoic acid, methyl ester | 0.12 | tetracoanoic acid, ethyl ester | 0.23 |
| sum | 99.5 | sum | 95.21 |

†The value area percent represents the percent for that particular compound of the total area for all compounds detected in that sample. It cannot be used for any purpose other than for discussion of the relative amount in that sample. Only those compounds for which identification with a high level of certainty are listed.

Qualitative results of the MS analysis of the exhaust from the various fuels are given in Table 6. The results are given only as an "X" for a given compound and test run, indicating that a given compound was both detected and identified with a high degree of certainty for that test run. These results are also depicted in Figures 14 through 20, summarized in terms of the relative percent of MS response in a given sample for several general classes of compounds which were detected. REE and RME showed the least $C_{13}$ - $C_{22}$ hydrocarbons. Of those compounds present, long-chain normal (unbranched) alkanes made up the majority. It would appear that many of the long-chain alkane- and alkene-based acid esters found in the fuels were fragmented at the oxygen bonds, resulting in simple alkanes and alkenes. The fuels contained several dienes but these did not appear in the exhaust. The carbon chain length in the fuels was primarily in the $C_{20}$ to $C_{22}$ range; however, the exhaust was primarily composed of $C_{16}$ through $C_{18}$ compounds. In the REE series, residual acid esters were detected in the $C_{16}$ through $C_{18}$ range. The catalyst-equipped runs for REE and RME were free of hydrocarbons in the $C_{12+}$ range, indicating that the catalyst was well optimized for these compound sizes and types.

The composition of the exhaust from the remaining fuels, 2-D and all of the blends, contained many similarities, as would be expected. The exhaust from 2-D fuel appeared much like the fuel itself: many straight-chain alkanes, distributed mainly among $C_{10}$ through $C_{19}$ with a peak around $C_{14}$. Exhaust from REE50, RME50, REE20, and RME20 followed this trend also. A number of aromatic (ring-containing) compounds and substituted alkanes were also found in the exhaust from this group. It should be noted that the exhaust from the blended fuels, REE50, RME50, REE20, and RME20, did not contain any compounds that were not also found in exhaust from the neat fuels, 2-D, REE, and RME. This means that there was no apparent production of unusual and/or toxic compounds through a synergism between diesel fuel and the esters, but rather that the heavier hydrocarbons remained composed primarily of unburned fuel components.

Another important finding for the diesel-containing fuels was the large number of compounds found in the catalyst-equipped runs. While the 100 percent rapeseed esters had no compounds in the $C_{12}$+ range, the presence of the diesel fuel component seems to have inhibited the action of the catalyst. Again, it is not possible to state whether there was any *reduction* due to the catalyst, because this work was not quantitative. However, essentially all the compounds found in the uncatalyzed runs were also found in those with the catalyst installed. As has been noted before, this catalyst was optimized to deal specifically with particle-associated hydrocarbons, and did not appear very effective in dealing with gaseous hydrocarbon emissions.

## TABLE 6. COMPOUNDS DETECTED AND IDENTIFIED BY MASS SPECTROGRAPHY FOR CUMMINS B 5.9L ENGINE WITH BIODIESEL FUELS

| Compound | 2-D | | 2-D, Cat | | REE | | REE, Cat | | RME | | RME, Cat | | REE50 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cold | Hot | Cold | Hot | Cold | Hot | Cold | Hot | Cold | Hot | Cold | Hot | Cold | Hot |
| 2-BUTOXY ETHANOL | - | - | - | - | | | | | - | - | - | - | - | X |
| BENZALDEHYDE | X | X | X | X | X | X | - | - | X | - | - | - | X | X |
| PHENOL | X | X | - | - | - | - | - | - | - | - | - | - | - | - |
| DECANE | X | X | X | X | - | - | - | - | - | - | - | - | X | X |
| LIMONENE | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| BENZALDEHYDE, METHYL | - | - | X | - | - | - | - | - | - | - | - | - | - | - |
| ETHANONE, PHENYL | X | - | - | - | - | - | - | - | - | - | - | - | - | - |
| UNDECANE | X | X | X | X | - | - | - | - | - | - | - | - | X | X |
| HEPENOIC ACID, ETHYL ESTER | - | - | - | - | X | X | - | - | - | - | - | - | - | - |
| BENZOIC ACID | X | X | - | - | X | - | - | - | - | - | - | - | X | X |
| NAPHTHALENE | X | X | X | X | X | - | - | - | X | X | - | - | X | X |
| DODECANE | X | X | X | X | - | - | - | - | - | - | - | - | X | X |
| DODECANE, METHYL | X | - | X | - | - | - | - | - | - | - | - | - | - | - |
| OCTANE, TRIMETHYL | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| UNDECANE, DIMEHTYL | X | X | X | X | - | - | - | - | - | - | - | - | - | - |
| 1,3-ISOBENZOFURANDIONE | X | X | X | - | - | - | - | - | - | - | - | - | - | X |
| NAPHTHALENE, TETRAHYDRO-METHYL | X | X | - | - | - | - | - | - | - | - | - | - | - | - |
| UNDECENOIC ACID, METHYL ESTER | - | - | - | - | - | - | - | - | X | - | - | - | - | - |
| TRIDECANE | X | X | X | X | - | - | - | - | - | - | - | - | X | X |
| NAPHTHALENE, METHYL | X | X | X | - | - | - | - | - | - | - | - | - | - | - |
| NAPHTHALENE, TETRAHYDRO-DIMETHYL | X | X | - | - | - | - | - | - | - | - | - | - | - | - |
| BENZENE, BUTENYL DIMETHYL | - | X | - | - | - | - | - | - | - | - | - | - | - | - |
| TETRADECENE | - | - | - | - | - | - | - | - | X | - | - | - | - | - |
| TETRADECANE | X | X | X | X | - | - | - | - | - | - | - | - | X | X |
| NAPHTHALENE, DIMETHYL | X | X | - | - | - | - | - | - | - | - | - | - | X | X |
| 1,1-BIPHENYL, METHYL | X | X | - | - | - | - | - | - | - | - | - | - | - | - |
| PENTADECANE | X | X | X | X | X | X | - | - | X | X | - | - | X | X |
| HEXADECENE | - | - | - | - | - | - | - | - | X | - | - | - | - | - |
| HEXADECANE | X | X | X | X | X | - | - | - | X | - | - | - | X | X |
| PENTADECANE, TETRAMETHYL | - | X | - | - | X | - | - | - | - | - | - | - | - | - |
| HEPTADECANE | X | X | X | X | X | - | - | - | - | - | - | - | X | X |
| OCTADECENE | - | - | - | - | - | - | - | - | X | X | - | - | - | - |
| OCTADECANE | - | X | - | X | X | X | - | - | X | X | - | - | X | X |
| NONDECANE | - | - | - | - | X | X | - | - | - | - | - | - | - | - |
| HEXADECANOIC, ACID, ETHYL ESTER | - | - | - | - | - | X | - | - | - | - | - | - | - | - |
| OCTADECENOIC ACID, METHYL ESTER | - | - | - | - | - | X | - | - | - | - | - | - | - | - |
| EICOSENE | - | - | - | - | - | - | - | - | - | X | - | - | - | - |

# TABLE 6 (CONT'D). COMPOUNDS DETECTED AND IDENTIFIED BY MASS SPECTROGRAPHY FOR CUMMINS B 5.9L ENGINE WITH BIODIESEL FUELS

| Compound | REE50,Cat | | RME50 | | RME50, Cat | | REE20 | | REE20, Cat | | RME20 | | RME20, Cat | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cold | Hot | Cold | Hot | Cold | Hot | Cold | Hot | Cold | Hot | Cold | Hot | Cold | Hot |
| 2-BUTOXY ETHANOL | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| BENZALDEHYDE | X | X | X | X | X | X | X | X | X | X | X | X | X | - |
| PHENOL | - | - | - | - | - | - | X | X | - | - | X | X | - | - |
| DECANE | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| LIMONENE | - | - | - | - | - | - | - | - | - | - | - | X | - | - |
| BENZALDEHYDE, METHYL | - | - | - | - | - | - | X | - | - | - | - | - | - | - |
| ETHANONE, PHENYL | - | - | - | - | - | - | X | - | - | - | - | - | - | - |
| UNDECANE | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| HEPENOIC ACID, ETHYL ESTER | - | - | - | - | - | - | - | - | - | -- | - | - | - | - |
| BENZOIC ACID | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| NAPHTHALENE | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| DODECANE | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| DODECANE, METHYL | - | - | - | - | - | - | - | - | - | X | - | - | X | X |
| OCTANE, TRIMETHYL | - | - | - | - | - | - | - | - | - | X | X | - | - | X |
| UNDECANE, DIMEHTYL | - | - | - | - | X | X | X | X | X | X | X | X | X | X |
| 1,3-ISOBENZOFURANDIONE | X | - | - | X | - | - | X | X | X | X | X | X | X | - |
| NAPHTHALENE, TETRAHYDRO-METHYL | - | - | X | X | - | - | X | X | X | - | X | X | X | - |
| UNDECENOIC ACID, METHYL ESTER | - | - | - | - | - | - | - | - | - | -- | - | - | - | - |
| TRIDECANE | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| NAPHTHALENE, METHYL | - | - | X | X | - | - | X | X | X | - | X | X | - | - |
| NAPHTHALENE, TETRAHYDRO-DIMETHYL | - | - | X | X | - | - | X | X | - | - | X | X | X | - |
| BENZENE, BUTENYL DIMETHYL | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| TETRADECENE | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| TETRADECANE | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| NAPHTHALENE, DIMETHYL | - | - | X | X | - | - | X | X | X | X | X | X | - | - |
| 1,1-BIPHENYL, METHYL | - | - | - | - | - | - | X | X | - | - | X | X | X | - |
| PENTADECANE | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| HEXADECENE | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| HEXADECANE | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| PENTADECANE, TETRAMETHYL | - | - | - | - | - | - | X | X | X | X | - | X | - | X |
| HEPTADECANE | - | X | X | X | X | X | X | X | X | X | X | X | X | X |
| OCTADECENE | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| OCTADECANE | - | - | - | - | - | X | X | X | X | X | X | X | X | X |
| NONDECANE | - | - | - | - | - | - | X | X | - | X | - | X | - | - |
| HEXADECANOIC, ACID, ETHYL ESTER | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| OCTADECENOIC ACID, METHYL ESTER | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| EICOSENE | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

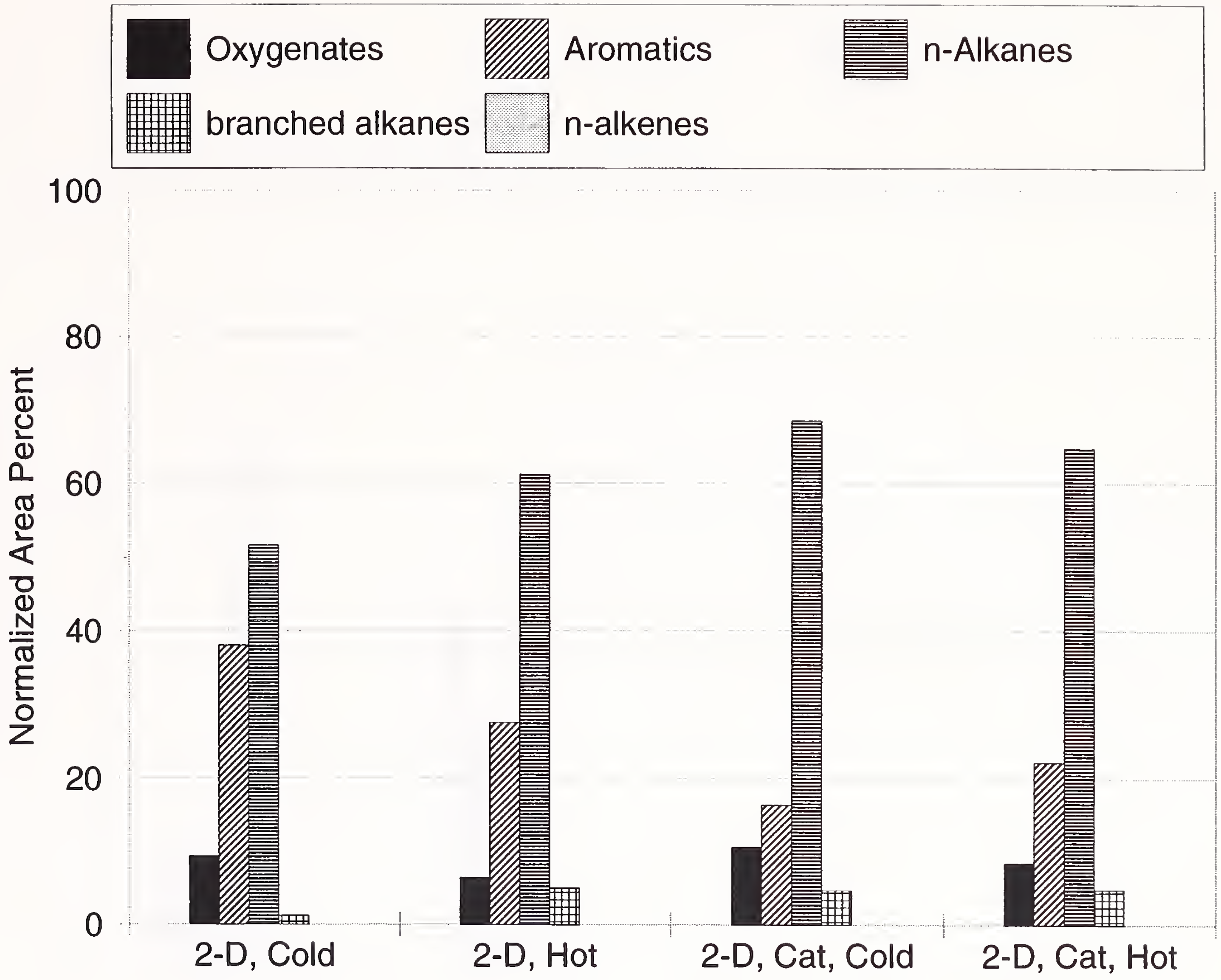

FIGURE 14. MASS SPECTROGRAPH DATA FOR DIFFERENT CLASSES OF COMPOUNDS IN EXHAUST, DIESEL FUEL

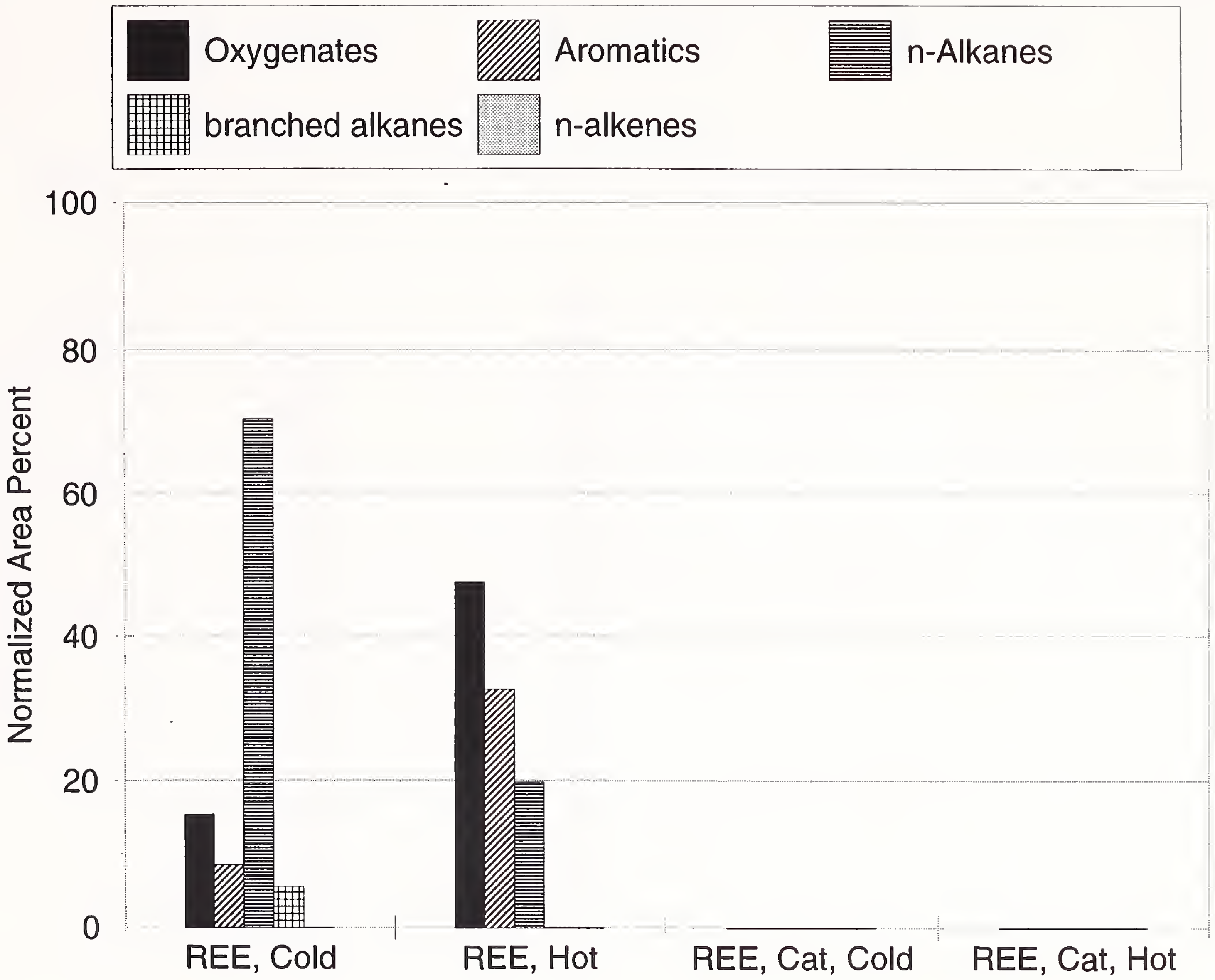

FIGURE 15. MASS SPECTROGRAPH DATA FOR DIFFERENT CLASSES OF COMPOUNDS IN EXHAUST, REE FUEL

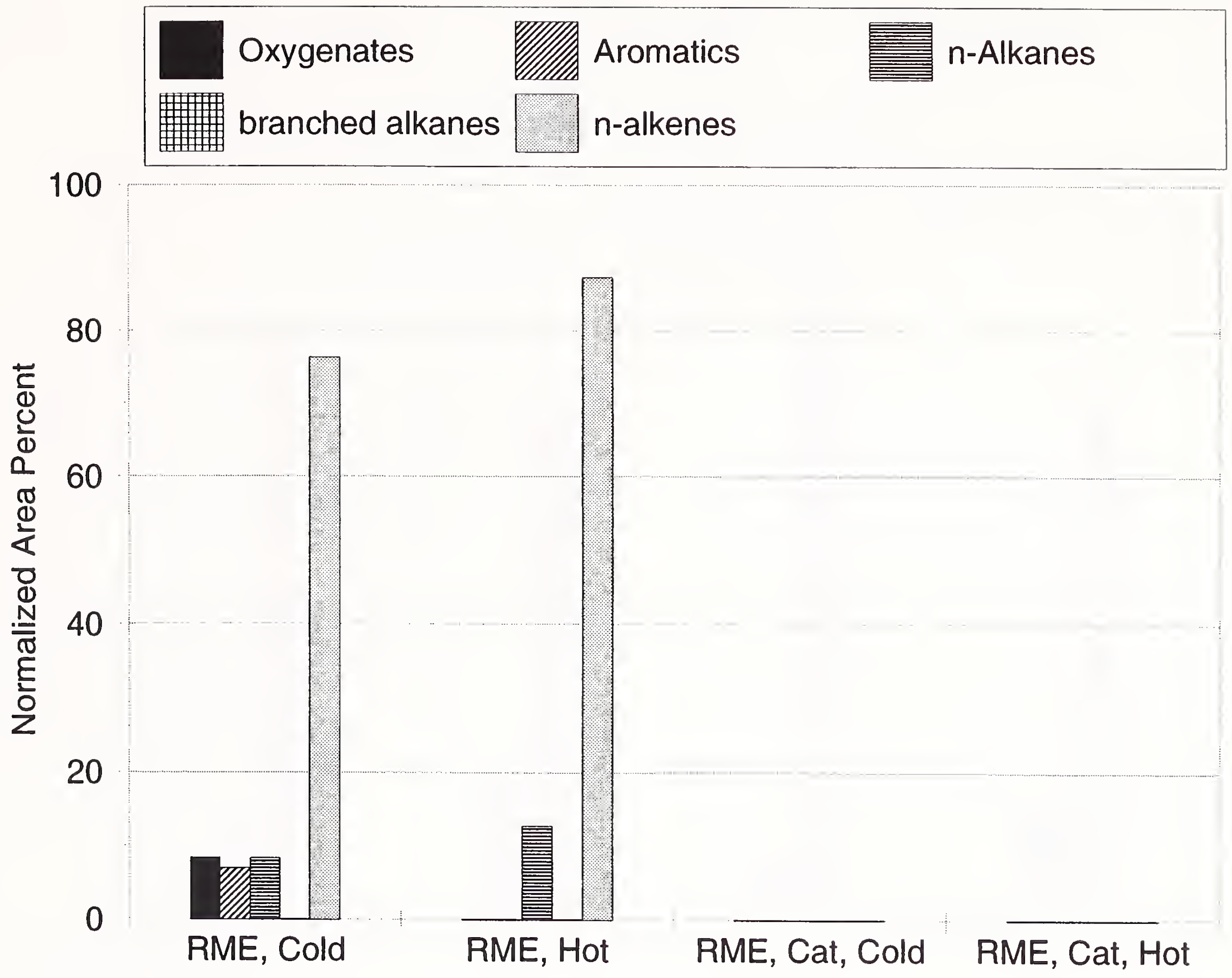

FIGURE 16. MASS SPECTROGRAPH DATA FOR DIFFERENT CLASSES OF COMPOUNDS IN EXHAUST, RME FUEL

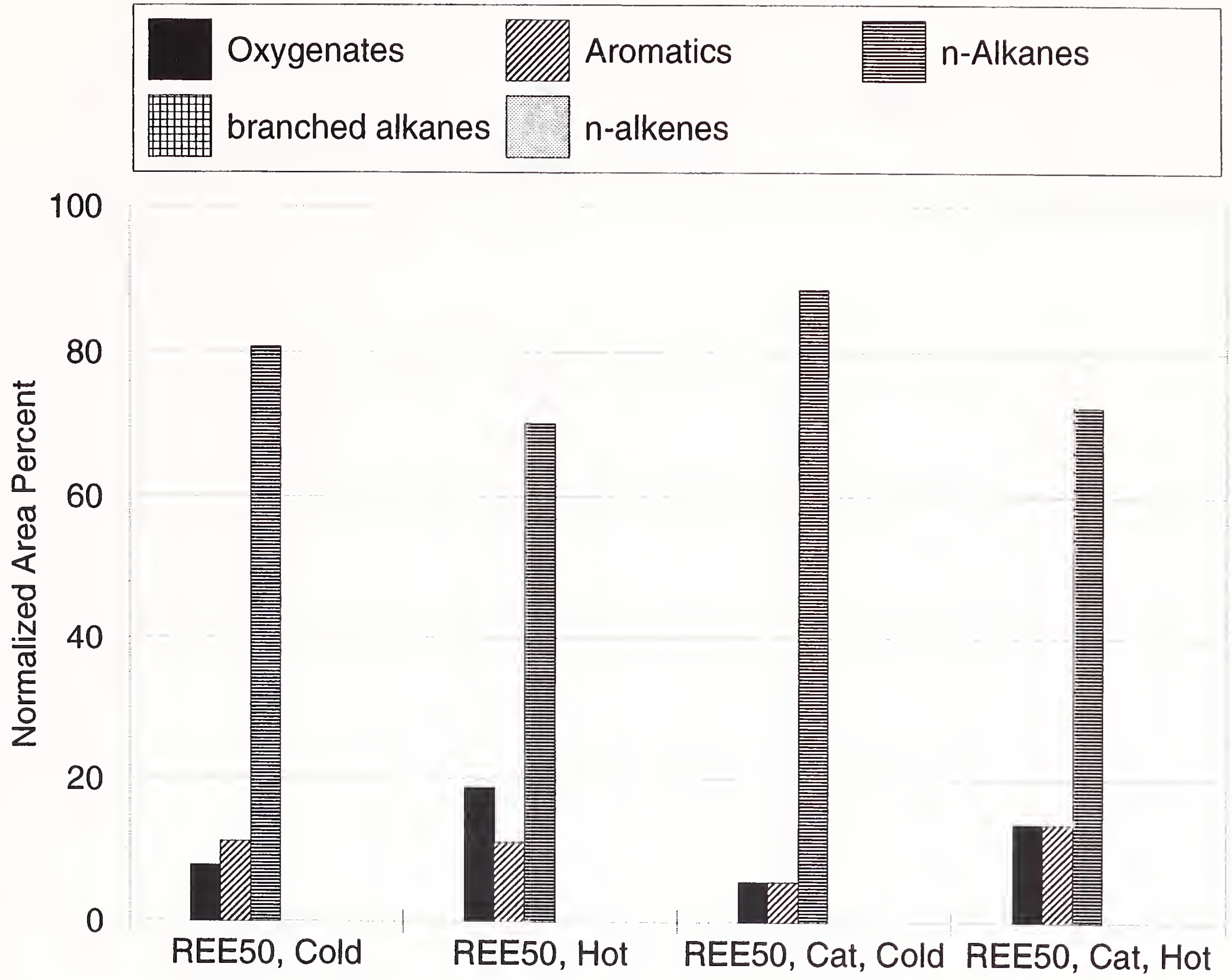

FIGURE 17. MASS SPECTROGRAPH DATA FOR DIFFERENT CLASSES OF COMPOUNDS IN EXHAUST, REE50 FUEL

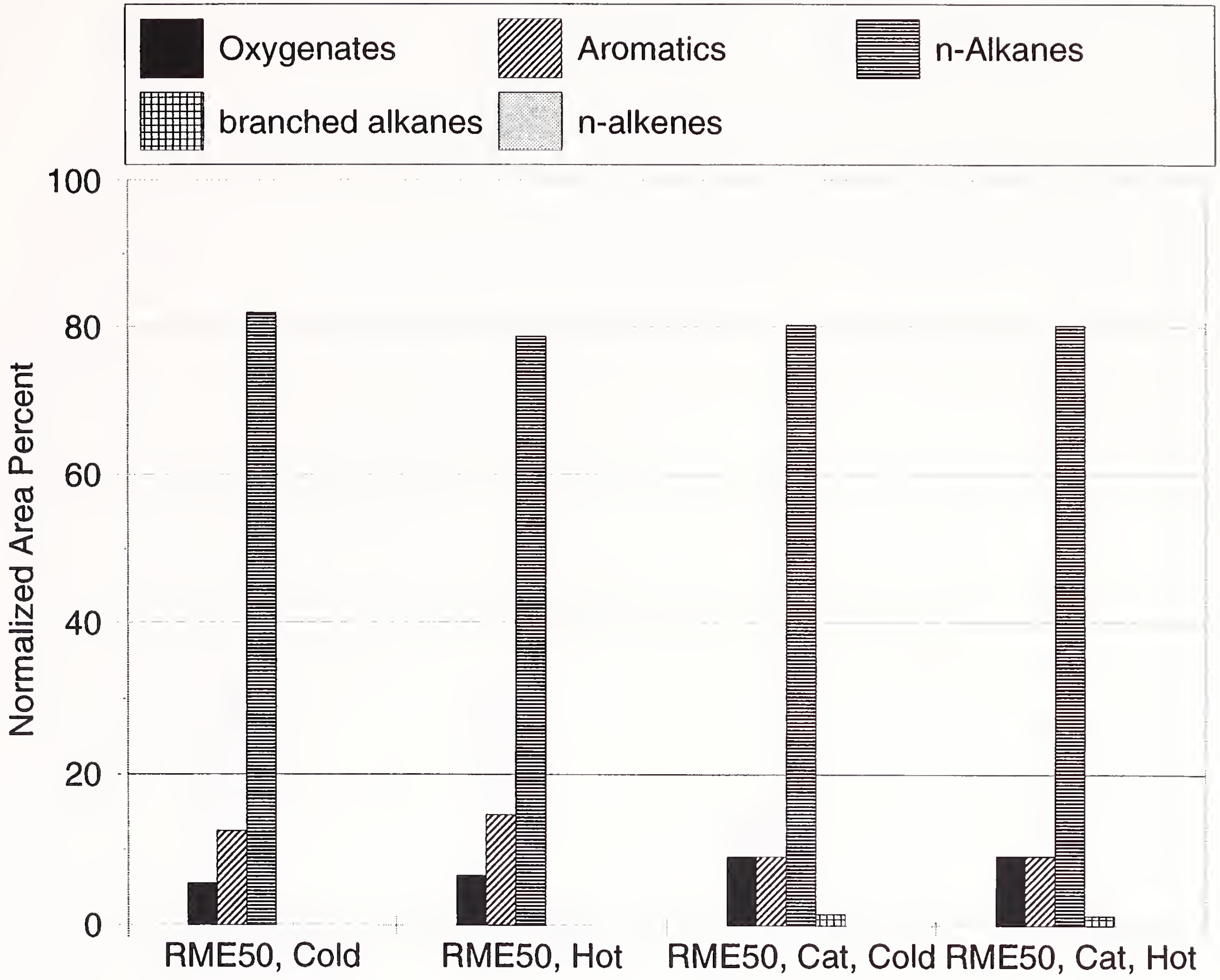

FIGURE 18. MASS SPECTROGRAPH DATA FOR DIFFERENT CLASSES OF COMPOUNDS IN EXHAUST, RME50 FUEL

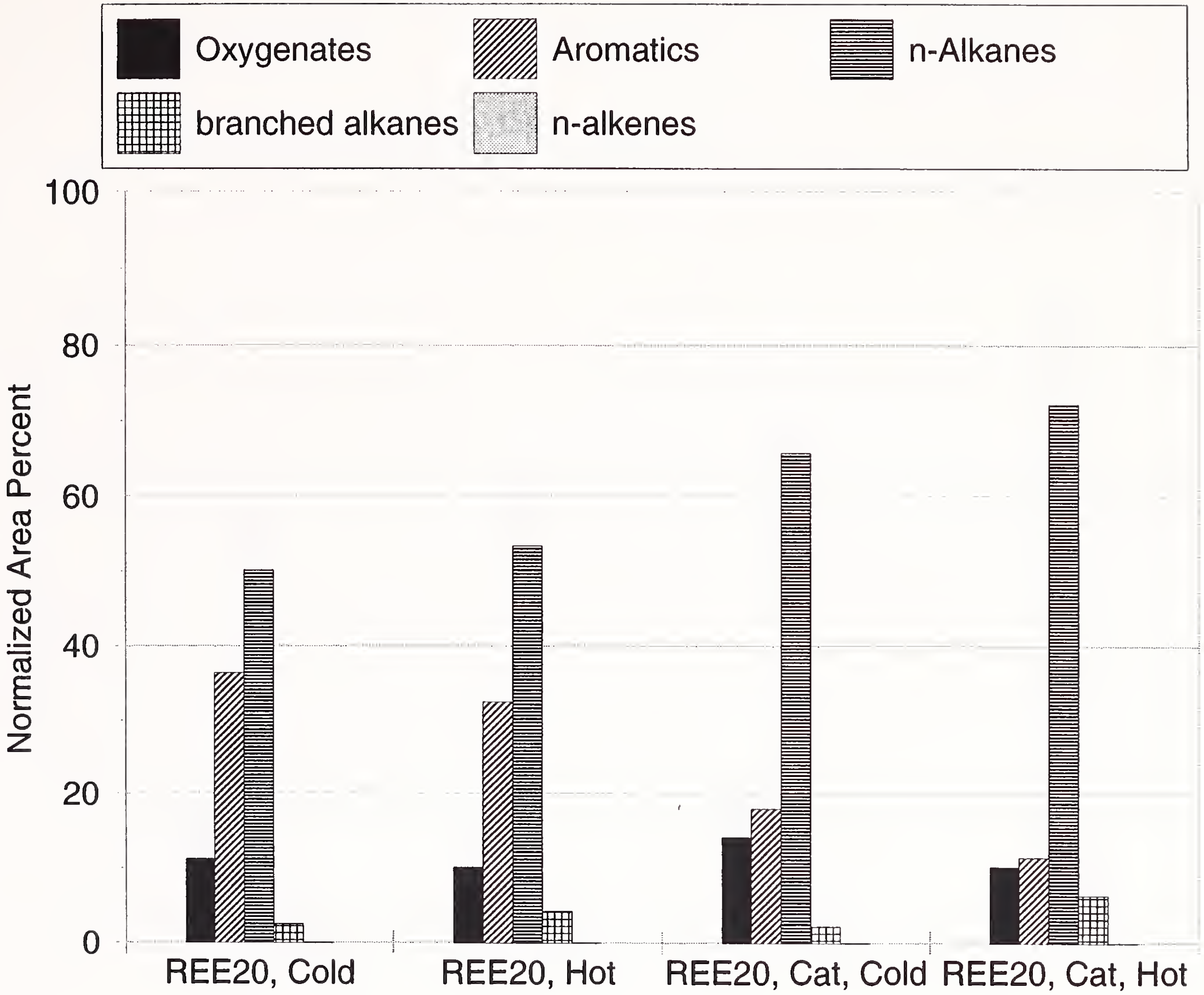

FIGURE 19. MASS SPECTROGRAPH DATA FOR DIFFERENT CLASSES OF COMPOUNDS IN EXHAUST, REE20 FUEL

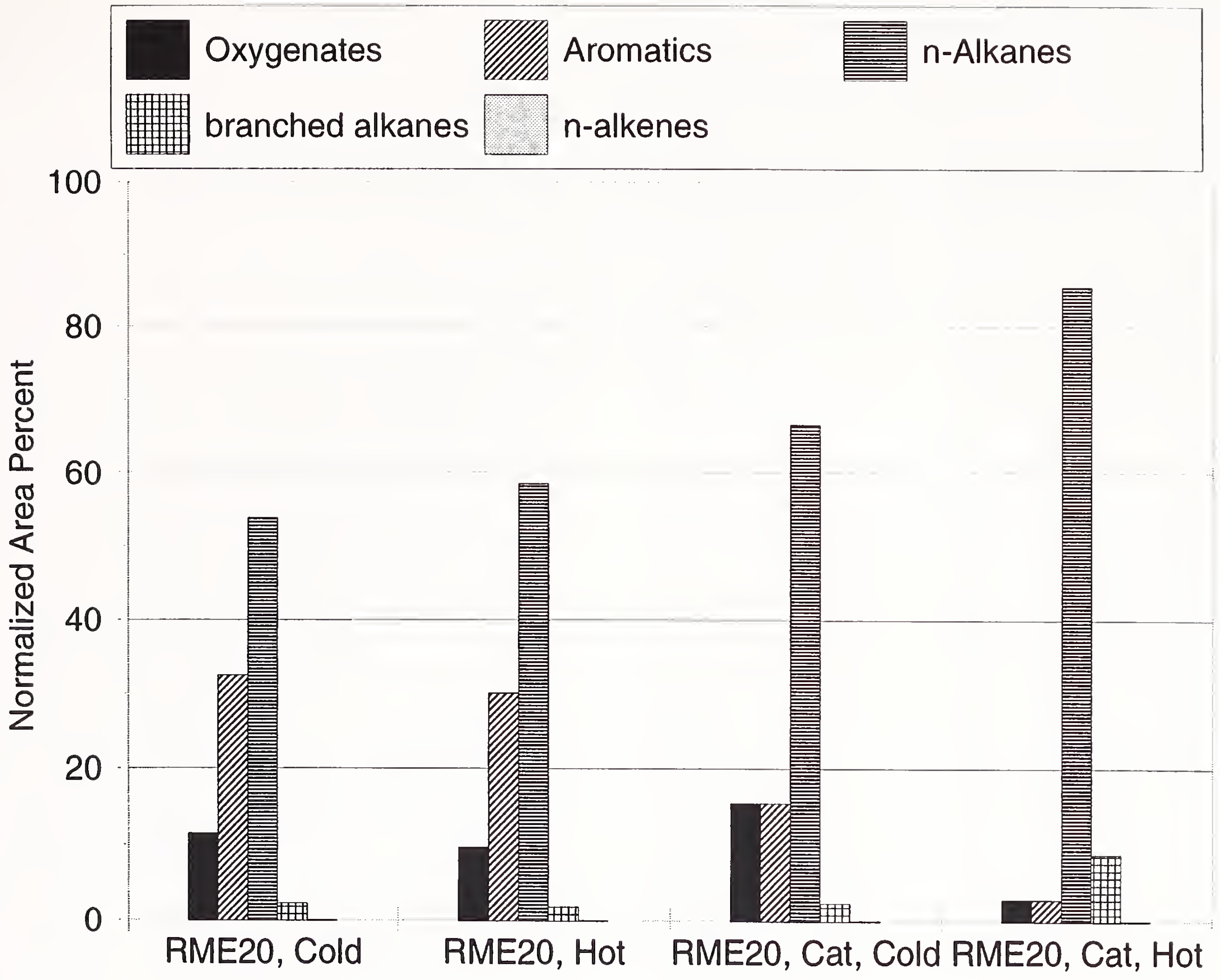

FIGURE 20. MASS SPECTROGRAPH DATA FOR DIFFERENT CLASSES OF COMPOUNDS IN EXHAUST, RME20 FUEL

## C. PAH Analysis

Data from PAH analysis of both gas-phase and particulate-phase samples is given in Table 7. The data for each compound measured are given as a cold-hot composite emission level in micrograms per horsepower-hour. In general, good separation was observed between gas-phase and particulate-phase compounds, with very little overlap between the PUFs and the filters. Gas -phase PAH compounds were present in much higher concentrations than the particulate-phase compounds, generally one to two orders of magnitude in most cases. Figures 21 through 26 depict PAH emissions for fuels REE, RME, REE50, RME50, REE20, and RME20 in comparison to 2-D fuel, both with and without catalyst. Because of the small relative mass of heavier compounds, all of the PAHs heavier than pyrene have been grouped and are summed under the classification "Other" on the graphs.

The 2-D fuel had a wide distribution of PAH compounds of the 18 compounds scanned for--only acenapthene, 1-nitropyrene, and dibenzo(a,h)anthracene, were not detected. As with all of the samples, the mass of gas phase compounds was generally several orders of magnitude greater than the mass of particulate phase compounds. The catalyst was effective in reducing nearly all of the PAH compounds, generally achieving a 50 percent or better conversion efficiency.

Both neat biodiesel fuels resulted in substantial decreases in total PAH mass, 40 and 50 percent for REE and RME. A closer examination of this change reveals that this reduction occurred entirely within the gas-phase PAH compounds, except for napthalene, which appeared unaffected by anything except the catalyst. The neat biodiesel fuels affected compounds in varying ways, with some compound levels decreasing, and others increasing. It should be noted, however that the total mass of each of these compounds was in the range of 1 microgram per horsepower-hour. The catalyst demonstrated its ability to remove PAH compounds from the exhaust, and in fact it achieved better conversion efficiency with the biodiesel fuels than with 2-D fuel The catalyst also controlled the levels of those particulate-phase PAH compounds that had increased with the neat biodiesel fuels to levels below those observed using the 2-D fuel.

The 50 percent blends fell part way between the 2-D fuel and the neat biodiesel fuels in terms of transient cycle PAH levels. As with the neat biodiesel fuels, the reductions in mass were essentially in the gas-phase compounds except for napthalene. RME50 achieved slightly lower levels of PAH than REE50. The particulate-phase compounds showed either no significant change, or increased to about the same levels as noted for the neat biodiesel fuels. Total mass of PAH

# TABLE 7. COMPOSITE PAH LEVELS FOR CUMMINS B5.9L ENGINE WITH BIODIESEL FUELS

| Fuel | Catalyst | Composite Mass (µg/hp-hr) Naphthalene [a] | Acenaphtylene [a] | Acenaphthene [a] | Fluorene [a] | Fluorenone [a] | Phenanthrene [a] | Anthracene [a] | Flouranthene [a] | Pyrene [b] | Benzo(a) anthracene [c] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2-D | No | 354 | 83 | ND | 109 | 76 | 226 | 13 | 122 | 30 | 1.0 |
| | Yes | 355 | 30 | ND | 59 | 160 | 162 | 4 | 61 | 11 | 0.4 |
| REE | No | 312 | 52 | ND | 25 | 22 | 71 | 5 | 126 | 13 | 0.8 |
| | Yes | 173 | 5 | ND | 11 | 11 | 36 | 2 | 62 | 7 | 0.3 |
| RME | No | 248 | 37 | ND | 13 | 12 | 38 | 9 | 100 | 16 | 0.7 |
| | Yes | 215 | 11 | ND | 13 | 16 | 38 | 2 | 62 | 13 | 0.2 |
| REE50 | No | 371 | 59 | ND | 45 | 36 | 103 | 7 | 134 | 23 | 1.3 |
| | Yes | 288 | 16 | ND | 16 | 22 | 11 | 1 | 71 | 6 | 0.4 |
| RME50 | No | 357 | 56 | ND | 64 | 27 | 107 | 7 | 75 | 16 | 0.3 |
| | Yes | 214 | 12 | ND | 19 | 16 | 45 | 2 | 50 | 5 | 0.3 |
| REE20 | No | 521 | 84 | ND | 98 | 64 | 170 | 10 | 129 | 21 | 1.1 |
| | Yes | 280 | 19 | ND | 29 | 40 | 78 | 2 | 62 | 6 | 0.3 |
| RME20 | No | 471 | 71 | ND | 87 | 56 | 160 | 9 | 119 | 19 | 1.1 |
| | Yes | 337 | 19 | ND | 29 | 11 | 78 | 3 | 63 | 7 | 0.4 |

| Fuel | Catalyst | Composite Mass (µg/hp-hr) Chrysene [c] | 1-Nitropyrene [c] | Benzo(b) fluoranthene [c] | Benzo(k) fluoranthene [c] | Benzo(e) pyrene [c] | Benzo(a) pyrene [c] | Indeno (1,2,30cd) pyrene [c] | Dibenzo (a,h)anthracene [c] | Benzo(g,h,i) perylene [c] | Total PAH [c] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2-D | No | 1.6 | ND | 0.6 | 0.6 | 0.6 | 0.3 | 0.4 | ND | 0.4 | 1017 |
| | Yes | 0.4 | ND | 0.2 | 0.1 | ND | ND | 0.2 | ND | 0.2 | 778 |
| REE | No | 1.8 | ND | 1.1 | 1.2 | 0.9 | 0.8 | ND | ND | 0.8 | 639 |
| | Yes | 0.4 | ND | 0.5 | 0.4 | 0.4 | 0.5 | ND | ND | 0.6 | 317 |
| RME | No | 1.0 | ND | 0.8 | 0.8 | 0.7 | 0.6 | 0.9 | ND | 0.8 | 472 |
| | Yes | 0.4 | ND | 0.9 | 0.4 | 0.9 | 0.4 | 0.8 | ND | 0.9 | 389 |
| REE50 | No | 1.7 | ND | 1.2 | 1.2 | 1.1 | 0.9 | 0.7 | ND | 0.6 | 789 |
| | Yes | 0.6 | ND | 0.6 | 0.5 | 0.5 | 0.8 | 0.3 | ND | 0.5 | 467 |
| RME50 | No | 1.1 | ND | 0.7 | 0.7 | 0.7 | 0.9 | 0.4 | 0.1 | 0.9 | 715 |
| | Yes | 0.4 | ND | 0.3 | 0.9 | 0.3 | 0.9 | 0.3 | ND | 0.4 | 364 |
| REE20 | No | 2.1 | ND | 0.9 | 0.9 | 0.9 | 0.8 | 0.4 | 0.1 | 0.9 | 1104 |
| | Yes | 0.6 | ND | 0.5 | 0.5 | 0.5 | 0.1 | 0.9 | ND | 0.5 | 516 |
| RME20 | No | 1.8 | ND | 0.8 | 0.7 | 0.7 | 0.7 | 0.4 | ND | 0.6 | 1003 |
| | Yes | 0.9 | ND | 0.5 | 0.5 | 0.5 | 1.2 | 0.4 | ND | 0.6 | 581 |

[a] Compounds were found in the gas-phase (PUF) samples, detection limit = 2.5 µg/hp-hr.
[b] Pyrene was detected in both gas-phase (PUF) samples and particulate filter samples.
[c] Compounds were found in the particulate-phase (filter) samples, detection limit = 0.02 µg/hp-hr.

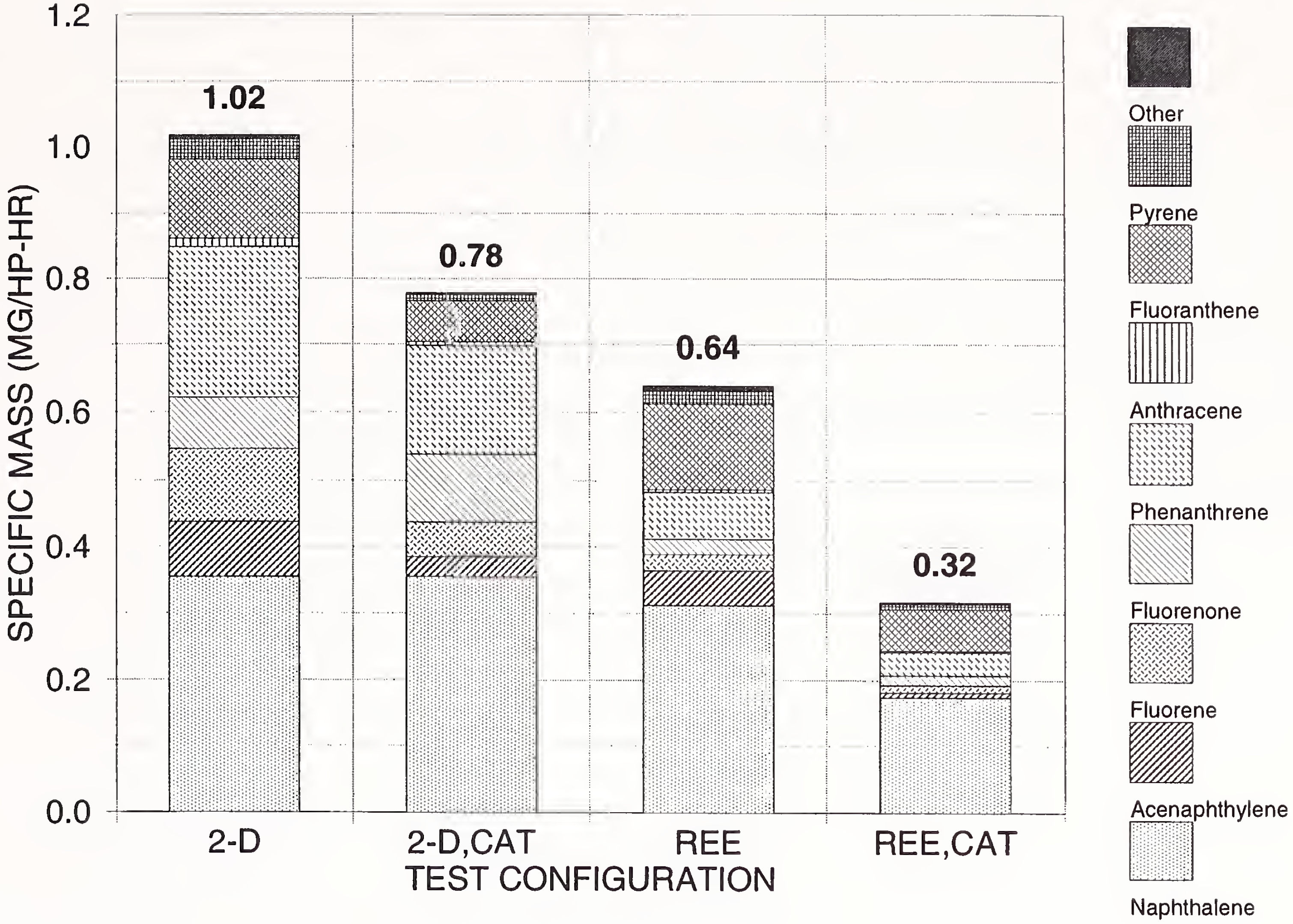

FIGURE 21. PAH DATA WITH AND WITHOUT CATALYST, EXHAUST FROM 2D AND REE FUELS

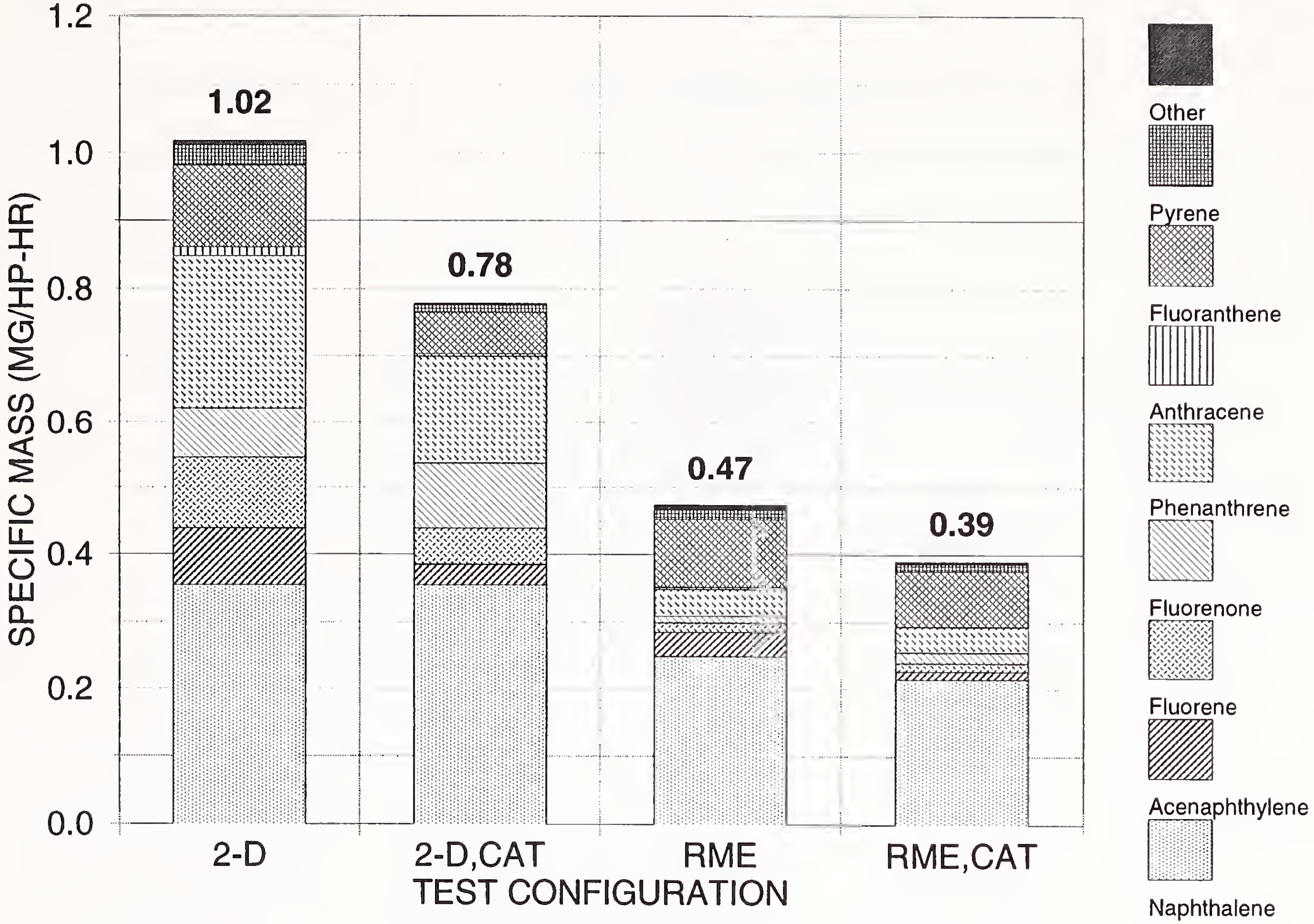

FIGURE 22. PAH DATA WITH AND WITHOUT CATALYST, EXHAUST FROM 2D AND RME FUELS

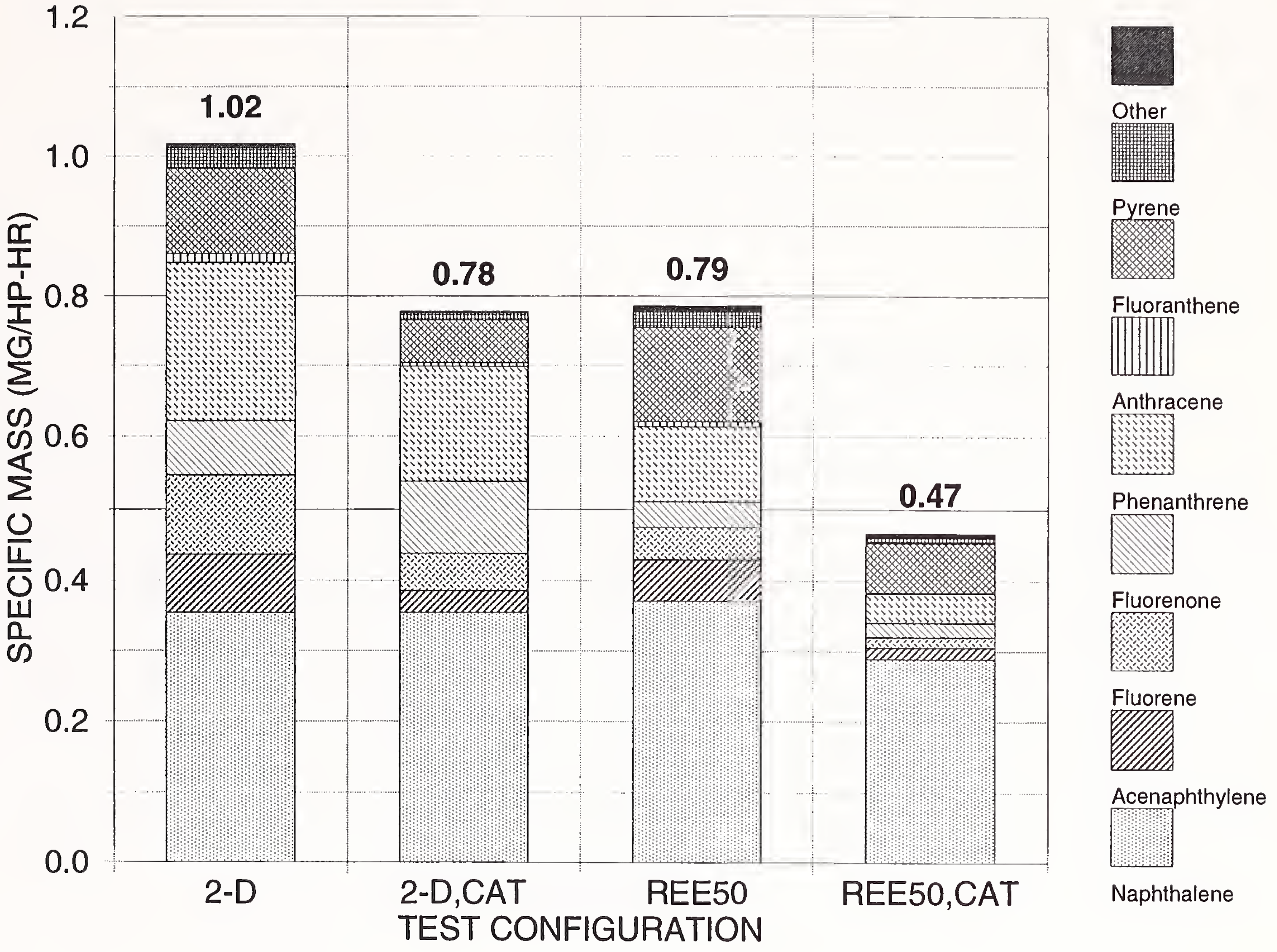

FIGURE 23. PAH DATA WITH AND WITHOUT CATALYST, EXHAUST FROM 2D AND REE50 FUELS

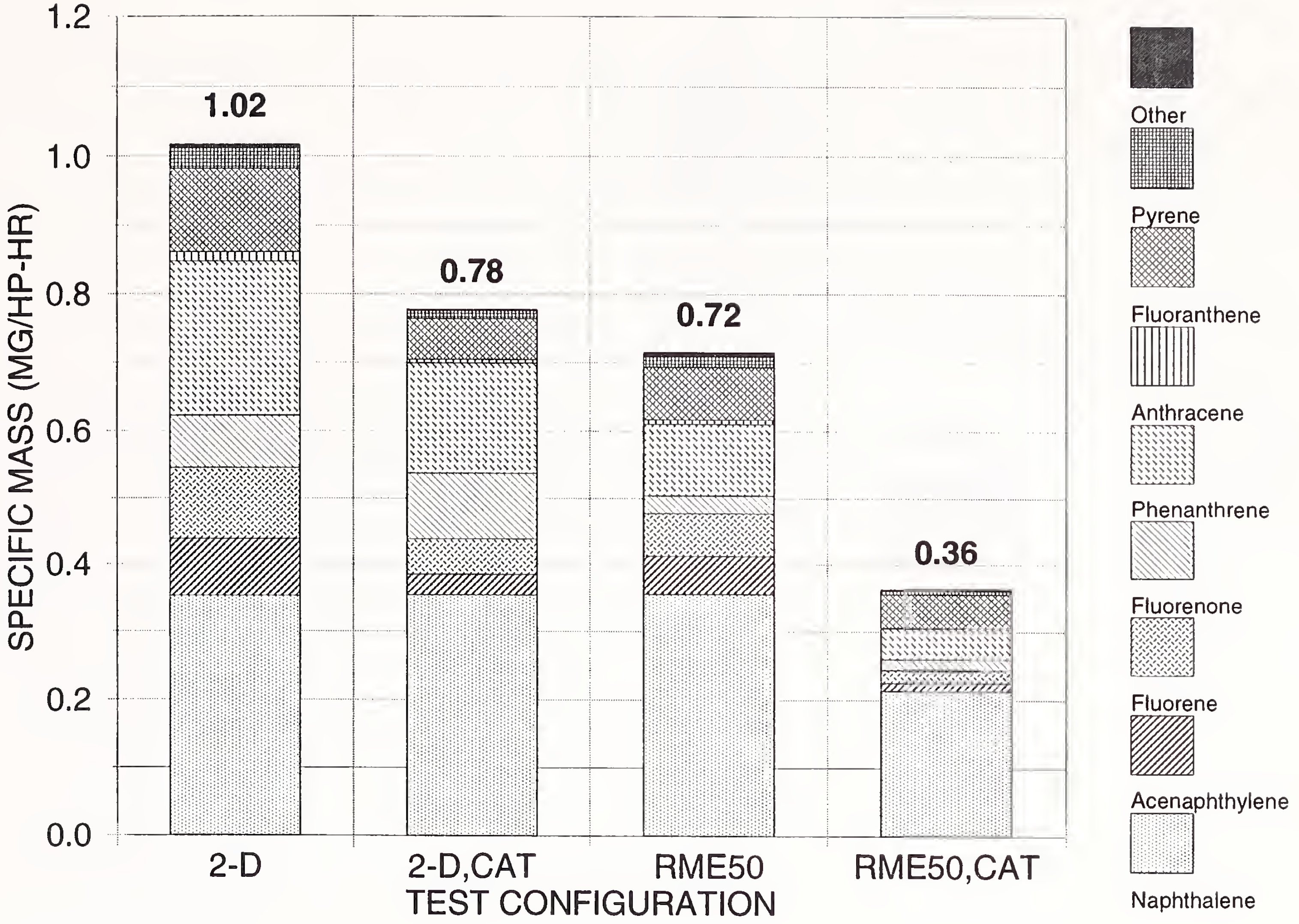

FIGURE 24. PAH DATA WITH AND WITHOUT CATALYST, EXHAUST FROM 2D AND RME50 FUELS

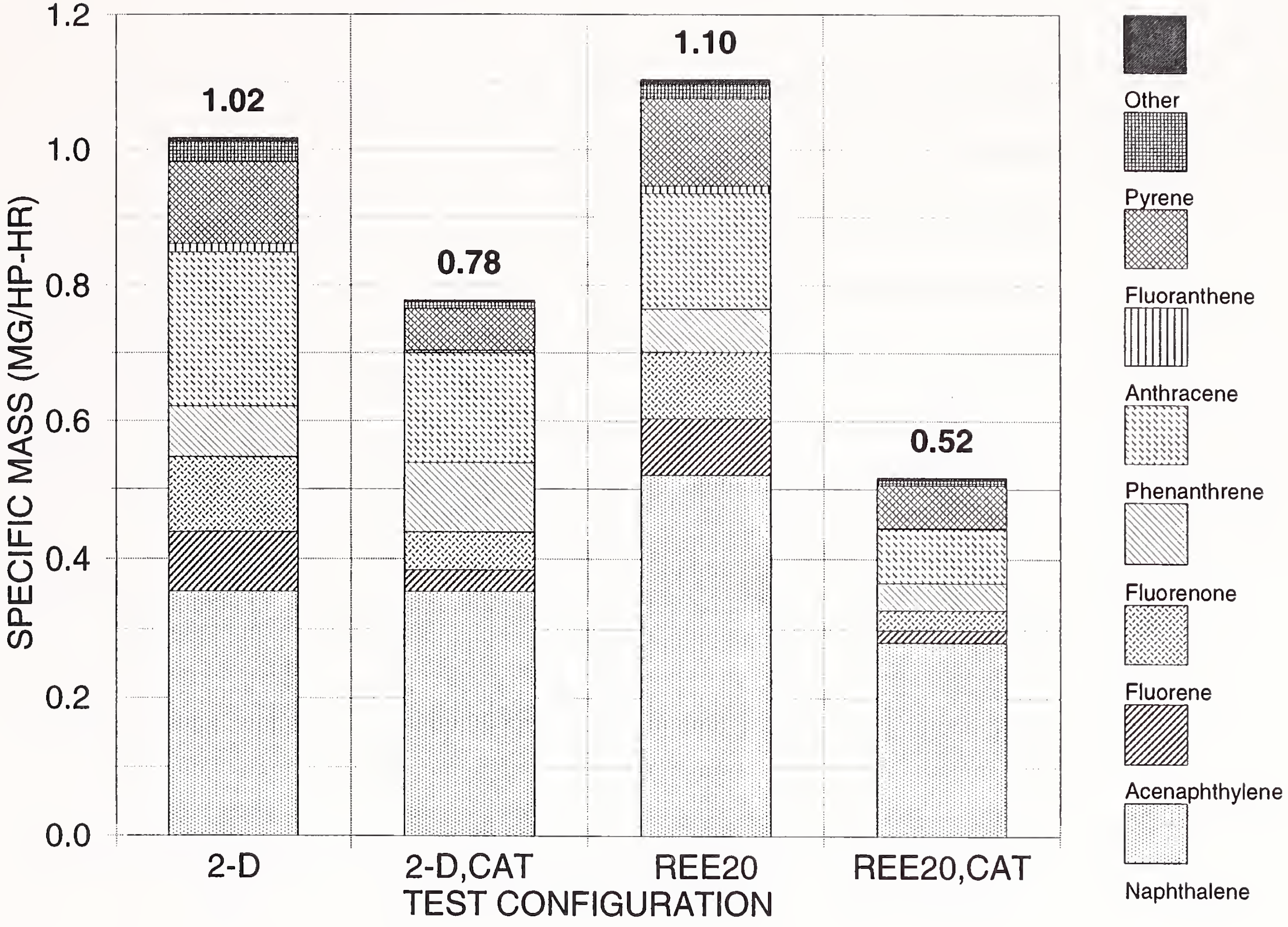

FIGURE 25. PAH DATA WITH AND WITHOUT CATALYST, EXHAUST FROM 2D AND REE20 FUELS

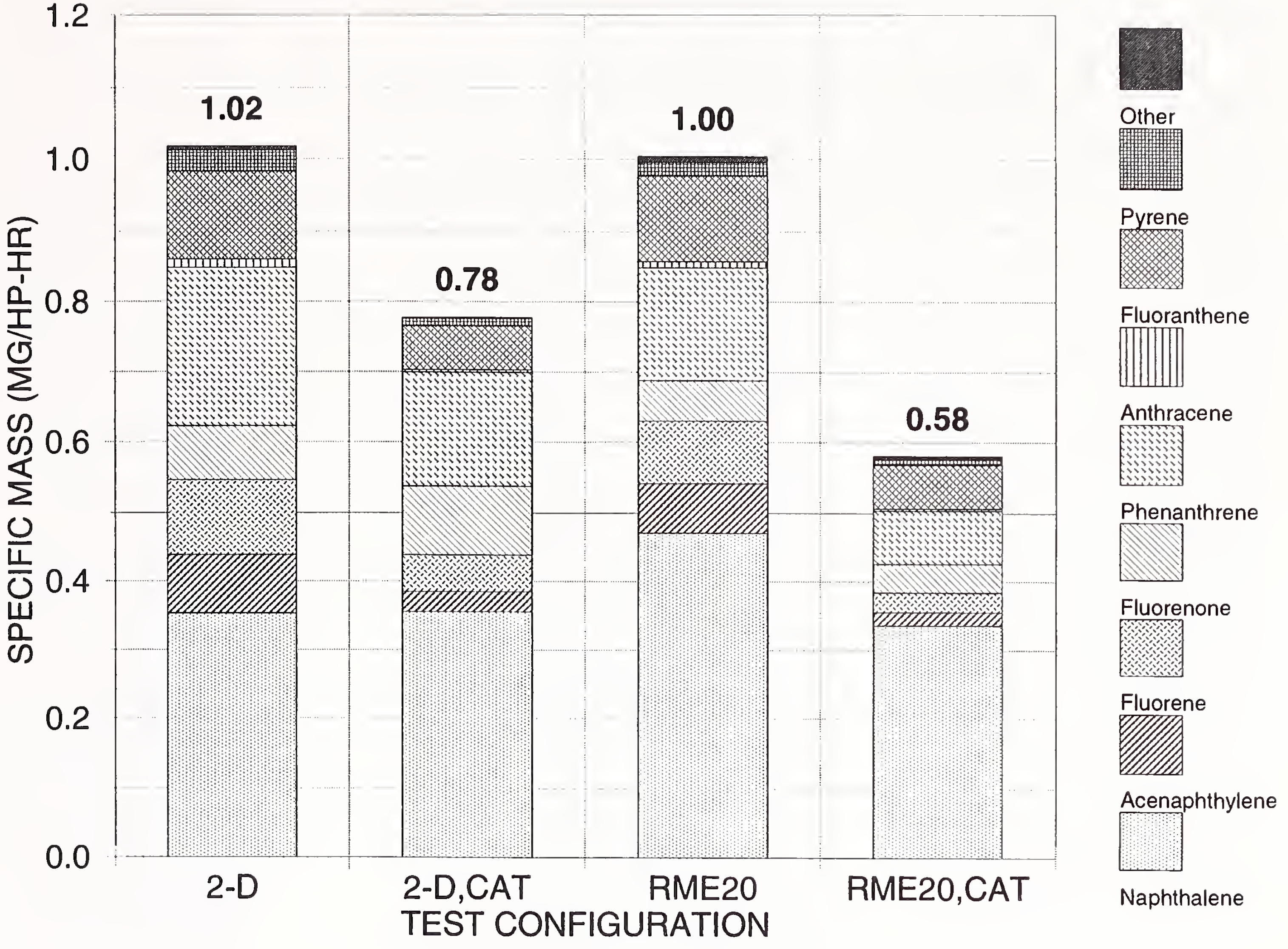

FIGURE 26. PAH DATA WITH AND WITHOUT CATALYST, EXHAUST FROM 2D AND RME20 FUELS

emissions with the 50 percent blends was similar to levels using 2-D fuel with a catalyst. Catalyst conversion efficiency with the 50 percent blends was higher than with 2-D fuel, but somewhat lower than the levels observed for the neat biodiesel fuels.

The 20 percent blends did not result in total PAH levels significantly different from 2-D fuel; and in the case of REE20, there was actually a slight increase, due mainly to napthalene. This correlates with the increase in speciated HC mass observed for REE20 without the catalyst. Both of the 20 percent blends had higher levels of napthalene, but lower levels of many of the heavier gas-phase compounds. Levels observed for the particulate-phase compounds with the 20 percent blends were the same as those measured for 2-D fuel. The major difference between 2-D fuel and the 20 percent blends was that the catalyst achieved a better conversion efficiency with the 20 percent blends, as was the case for the other biodiesel test fuels.

PAH data were forwarded to Walter Switzer in the SwRI Biomedical Science group for a preliminary assessment. The assessment dealt only with the neat fuels, and the full text of that assessment is given in Appendix D. In summary, the assessment indicated that there appeared to be differences in the concentration profiles of PAHs produced by the different fuel types. This data set indicated that diesel fuel produces the lowest levels of the most potent (identified) compound, benzo(*a*)pyrene. However, it should be noted that none of the test fuels produced benzo(a)pyrene levels anywhere near the 10 ppb recommended exposure limit set by NIOSH. The same data set indicated that the biofuels produced lower levels of almost all the other compounds found. These assessments were based on an examination of the data, not a statistical analysis. However, the trends observed probably would benefit by at least a nonparametric analysis and further examination of the data.

## D. Lubricity Testing

Test results obtained from both the SLBOCLE and HFRR apparatuses are provided in Table 8. The SLBOCLE shows that all of the fuels tested had excellent lubricity. Nonetheless, the lubricity of both Biodiesel fuels was significantly better than that of the conventional diesel fuel. The REE fuel may have shown marginally better lubricity characteristics than the RME fuel. The HFRR apparatus showed directionally similar results to the BOCLE. However, the HFRR apparatus indicated that the conventional diesel fuel has only marginal to poor lubricity.

Both the SLBOCLE and the HFRR confirm that blending biodiesel with conventional diesel fuel results in a significant improvement in lubricity compared to diesel fuel alone. A slight improvement in lubricity was apparent at biodiesel concentrations down to 20 percent. Significantly more improvement would be

expected if the biodiesel were blended to a very low lubricity fuel, such as kerosene.

## TABLE 8. LABORATORY SCALE WEAR TEST RESULTS

| Fuel | SLBOCLE, grams | | | HFRR, mm |
|---|---|---|---|---|
| | Run 1 | Run 2 | Average | |
| 2-D | 4200 | 4300 | 4250 | 0.405 |
| REE | >7000 | >7000 | >7000 | 0.085 |
| RME | 7000 | >7000 | 7000 | 0.140 |
| 50%RME 50%REF | 5500 | 5600 | 5550 | 0.165 |
| 20%RME 80%REF | 4500 | 4700 | 4600 | 0.190 |
| 50%REE 50%REF | 5600 | 5800 | 5700 | 0.165 |
| 20%REE 80%REF | 4600 | 4800 | 4700 | 0.165 |

# IV. CONCLUSIONS

In evaluating all of the results of transient testing using RME and REE, both as neat fuels and in blends, several overall points are apparent in comparing the transient emissions levels associated with biodiesel fuels to emission levels associated with diesel fuel.

The presence of oxygen in biodiesel is one of the major factors that drives many of the differences observed in transient emission levels. Figure 27 shows plots of composite HC and CO levels versus oxygen content, and Figure 28 plots total particulate emissions and the soot portion of the particulate against oxygen content. As can be seen in these graphs, increasing oxygen content results in decreased HC, CO, and particulate levels. The decrease in total particulate emissions was associated with a decrease in carbon soot levels, as shown in Figure 28.

Figure 29 shows plots of both total particulate and VOF levels as a function of the percent biodiesel in the fuel by volume. Although total particulate emissions decreased, the VOF level increased as biodiesel content increased. This increase in VOF offset the reduction in the soot portion of the total particulate, thus limiting the decrease in the total particulate level observed with biodiesel fuels. Increased levels of VOF are likely because biodiesel fuel is made up of only a narrow range of esters, around the $C_{18}$ range. Therefore, unburned biodiesel tends to condense as particulate rather than as gaseous HC emissions.

Although there are emission advantages over diesel fuel, the disadvantages of biodiesel were a small drop in the engine performance and a worsening of BSFC (fuel economy). These changes were essentially due to the lower energy content of biodiesel fuel, as reflected by its lower heating value. Blends of biodiesel with diesel fuel lessened this impact, so that the performance of the 20 percent blends was very similar to that of diesel fuel, while engine performance with the 50 percent blends fell part way between that of neat biodiesel and diesel fuel.

Tests were also conducted on all of the fuels with the catalyst. In general, the catalyst performed better (had better conversion efficiency) when the engine was fueled on biodiesel than when fueled on diesel fuel. HC, CO, and total particulate emissions, as well as PAH, along with $C_{13}$ and heavier hydrocarbons, were all more efficiently reduced by the catalyst. The fraction of the particulate composed of VOF increased with biodiesel fuels. With the $C_{13}$ and heavier hydrocarbons, it may be that the species present in the exhaust, when using

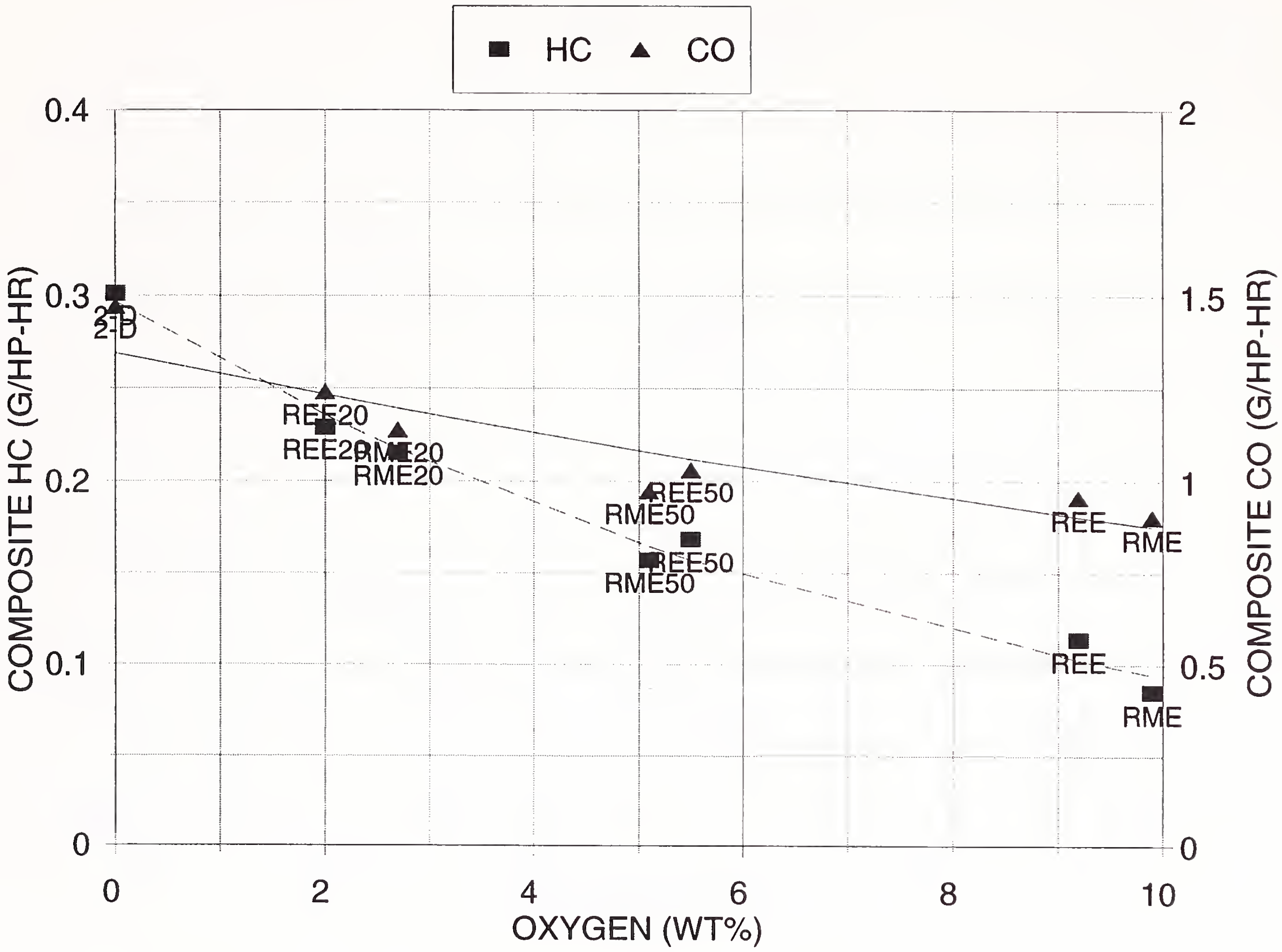

FIGURE 27. COMPOSITE HC AND CO LEVELS VERSUS OXYGEN WEIGHT PERCENT IN FUEL WITHOUT CATALYST

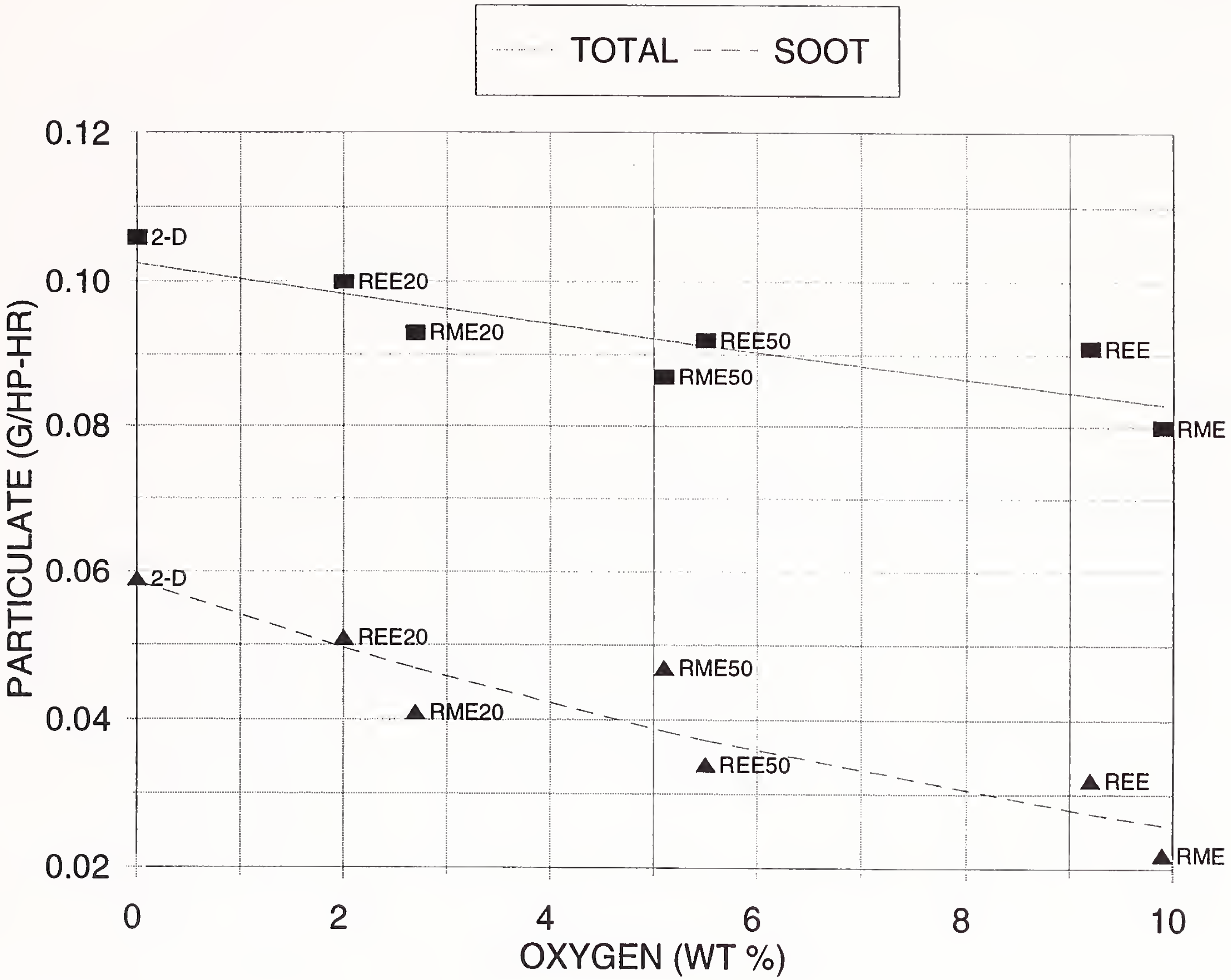

FIGURE 28. COMPOSITE TOTAL PARTICULATE AND SOOT LEVELS VERSUS OXYGEN WEIGHT PERCENT IN FUEL WITHOUT CATALYST

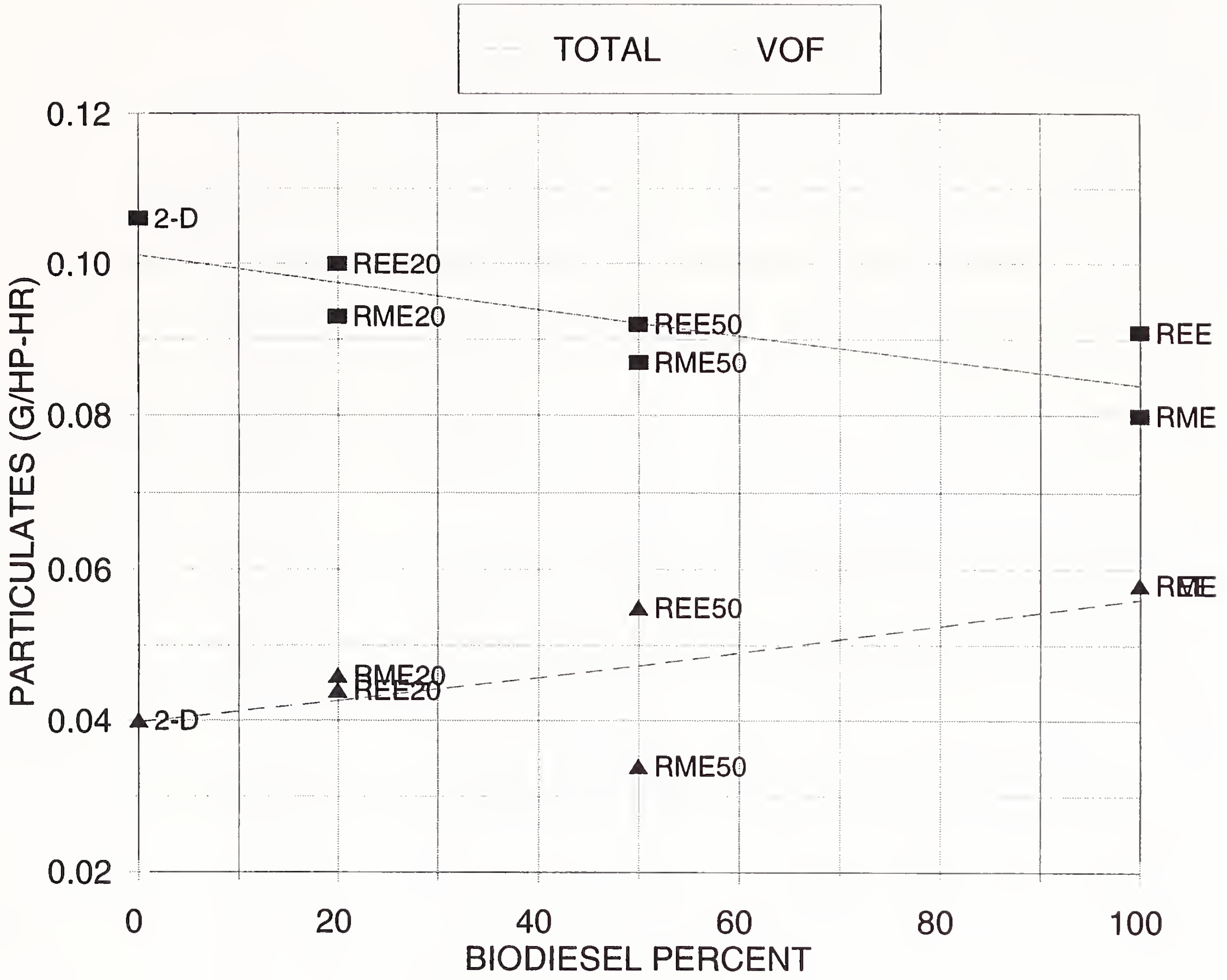

FIGURE 29. COMPOSITE TOTAL PARTICULATE AND VOF LEVELS VERSUS VOLUME PERCENT BIODIESEL IN FUEL WITHOUT CATALYST

biodiesel fuels, were easier for the catalyst to destroy. This would help explain the higher catalytic efficiency in reducing HC emissions. The reason for higher catalyst efficiency with biodiesel on CO and PAH emissions, and to a lesser extent HC emissions, is not readily apparent. More detailed study would be needed to fully examine the relationship between catalyst and biodiesel exhaust constituents.

Hydrocarbon speciation data indicated that biodiesel also had a beneficial effect on the character of the HC emissions, and their net ozone reactivity. With biodiesel, speciation data for hydrocarbons ranging from $C_1$ to $C_{12}$ carbon number indicated both a reduced mass of hydrocarbons and a reduced potential for ozone formation compared to HC emissions associated with diesel fuel. This effect appeared to increase in proportion to the amount of biodiesel in the fuel. GC/MS data for hydrocarbons having thirteen or more carbons ($C_{13}$+) indicated that emissions associated with neat biodiesel fuels had far fewer species in the exhaust than when diesel fuel was used. Speciation data associated with biodiesel blends indicated that such blends did not appear to form any unusual and/or toxic hydrocarbons in the $C_{13}$ to $C_{22}$ carbon range. It should be noted that when neat biodiesel fuels and the catalyst were used, no exhaust hydrocarbons in the $C_{13}$ and higher carbon range were detected.

PAH data indicated that biodiesel also decreased the total transient cycle PAH levels in the exhaust. The decreases occurred mainly in the gas-phase PAH compounds, which formed the overwhelming fraction of the total PAH mass. Some of the particulate-phase compounds were reduced with biodiesel, while a few were increased. The catalyst was able to control increases levels of particulate-phase compounds associated with biodiesel. On biodiesel, the catalyst also appeared to have increased conversion efficiency for unnecessary gas-phase compounds as compared to diesel fuel.

Lubricity testing indicated that both REE and RME had excellent lubricity, and ranked better than almost all commercially available diesel fuels. Blending as low as 20 percent biodiesel with conventional diesel fuels significantly improved lubricity of the fuels.

# APPENDIX A

# INDIVIDUAL TRANSIENT TEST RESULTS

```
                                SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                            EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                  TEST  A-C1           RUN                DIESEL   2D       EM-2045-F
ENGINE MODEL  95 CUMMINS                        DATE 10/31/95   TIME                    HCR 1.80  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6                   COMPUTER PROGRAM  HDT 3.4-R             H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                           CELL  7      BAG CART 1                 ENGINE OIL
ENGINE SERIAL  56219753                         DIESEL

BAROMETER 740.2 MM HG (29.14 IN HG)     CVS:  71.0°F  RH 69. PCT  AH  80.2 GR/LB        ENGINE DEW PT. 13.4°C (56.1°F)
ENGINE AIR TEMP. 25.0°C (77.0°F)        ENGINE: RH 48. PCT  AH  9.9 G/KG ( 69.1 GR/LB)  NOX HUMIDITY C.F.   .985
                                        REFERENCE WORK  9.17 KW HR (12.30 HP HR)        DRY-TO-WET C.F.   .976
BAG RESULTS
  BAG NUMBER                                    1
  TIME SECONDS                               1207.3
  TOT. BLOWER RATE SCMM (SCFM)            33.60 (1186.4)
  TOT. 90MM RATE SCMM (SCFM)                .06 ( 2.21)
  TOT. 20X20 RATE SCMM (SCFM)              1.52 ( 53.6)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)         .09 ( 3.32)
  TOTAL FLOW STD. CU. METRES(SCF)         709.8 ( 25064.)

  HC  SAMPLE METER/RANGE/PPM               .2/ 76/  16.75
  HC  BCKGRD METER/RANGE/PPM               .1/ 76/   4.94
  CO  SAMPLE METER/RANGE/PPM             32.0/ 12/  31.15
  CO  BCKGRD METER/RANGE/PPM               .7/ 12/    .66
  CO2 SAMPLE METER/RANGE/PCT             74.9/ 11/  .6462
  CO2 BCKGRD METER/RANGE/PCT              8.8/ 11/  .0520
  NOX SAMPLE METER/RANGE/PPM (D)           .5/ 73/  44.92
  NOX BCKGRD METER/RANGE/PPM              1.1/  2/   1.10

  DILUTION FACTOR                              20.91
  HC  CONCENTRATION PPM                        12.05
  CO  CONCENTRATION PPM                        29.46
  CO2 CONCENTRATION PCT                        .5967
  NOX CONCENTRATION PPM                        42.79

  HC  MASS GRAMS                                4.912
  CO  MASS GRAMS                               24.347
  CO2 MASS GRAMS                             7748.76
  NOX MASS GRAMS                               57.212
  FUEL  KG (LB)                           2.451 (  5.40)
  KW HR (HP HR)                            9.45 ( 12.67)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .520(   .388) (   .39) (CONT)     90 MM FLTR NUMBERS          P90-1       P90-
  BSCO   G/KW HR (G/HP HR)       2.577(  1.922) (  1.92)            90 MM FLTR WT. GAINS (MG)     2.768          .000
  BSNOX  G/KW HR (G/HP HR)       6.055(  4.516) (  4.52) (CONT)     PARTICULATE GRAMS/TEST              1.559
  PART.  G/KW HR (G/HP HR)        .165(   .123) (   .12)
  BSFC  KG/KW HR (LB/HP HR)       .259(   .427)
  WORK      KW HR (HP HR)         9.45(  12.67)
  BSCO2  G/KW HR (G/HP HR)       820. (   612.)
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                        SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                               TEST  A-C1           RUN            DIESEL    2D       EM-2045-F
ENGINE MODEL  95 CUMMINS                     DATE 10/31/95   TIME                HCR 1.80  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                 COMPUTER PROGRAM  HDT 3.4-R         H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                        CELL  7      BAG CART 1             ENGINE OIL
ENGINE SERIAL  56219753                      DIESEL

BAROMETER 740.2 MM HG (29.14 IN HG)    CVS:  71.0°F  RH 69. PCT  AH  80.2 GR/LB       ENGINE DEW PT. 13.4°C (56.1°F)
ENGINE AIR TEMP. 25.0°C (77.0°F)       ENGINE: RH 48. PCT  AH  9.9 G/KG ( 69.1 GR/LB) NOX HUMIDITY C.F.  .985
                                       REFERENCE WORK  9.17 KW HR (12.30 HP HR)       DRY-TO-WET C.F.   .976

                            SAMPLE              BACKGROUND
  FORMALDEHYDE
    PPM                       .644                .004
    MASS  MG                553.77
  ACETALDEHYDE
    PPM                       .154                .000
    MASS  MG                195.65
  ACROLEIN
    PPM                       .008                .000
    MASS  MG                 13.12
  ACETONE
    PPM                       .036                .005
    MASS  MG                 53.00
  PROPIONALDEHYDE
    PPM                       .018                .000
    MASS  MG                 30.94
  CROTONALDEHYDE
    PPM                       .040                .000
    MASS  MG                 81.68
  ISOBUTYR+MEK
    PPM                       .014                .000
    MASS  MG                 29.26
  BENZALDEHYDE
    PPM                       .007                .000
    MASS  MG                 20.93
  HEXANALDEHYDE
    PPM                       .007                .000
    MASS  MG                 19.64

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR          43.707         CROTONALD.    MG/HP-HR           6.447
              ACETALDEHYDE MG/HP-HR          15.442         ISOBUTYR+MEK  MG/HP-HR           2.309
              ACROLEIN     MG/HP-HR           1.036         BENZALDEHYDE  MG/HP-HR           1.652
              ACETONE      MG/HP-HR           4.183         HEXANALDEHYDE MG/HP-HR           1.550
              PROPIONALD.  MG/HP-HR           2.442
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                              SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                        EPA  HOT TRANS  ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                 TEST  A-H1          RUN                 DIESEL   2D       EM-2045-F
ENGINE MODEL  95 CUMMINS                       DATE 10/31/95   TIME                    HCR 1.80  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                   COMPUTER PROGRAM  HDT 3.4-R             H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                          CELL  7      BAG CART 1                 ENGINE OIL
ENGINE SERIAL  56219753                        DIESEL

BAROMETER 740.4 MM HG (29.15 IN HG)     CVS:  74.0°F  RH 62. PCT  AH  80.1 GR/LB       ENGINE DEW PT. 13.3°C (56.0°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)        ENGINE: RH 45. PCT  AH  9.8 G/KG ( 68.8 GR/LB)  NOX HUMIDITY C.F.  .984
                                        REFERENCE WORK  9.17 KW HR (12.30 HP HR)        DRY-TO-WET C.F.   .976
BAG RESULTS
  BAG NUMBER                                     1
  TIME SECONDS                                1207.4
  TOT. BLOWER RATE SCMM (SCFM)             34.00 (1200.7)
  TOT. 90MM RATE SCMM (SCFM)                 .06 ( 2.29)
  TOT. 20X20 RATE SCMM (SCFM)               1.52 ( 53.7)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)          .09 ( 3.25)
  TOTAL FLOW STD. CU. METRES(SCF)          718.0 ( 25354.)

  HC  SAMPLE METER/RANGE/PPM                 .2/ 76/  13.09
  HC  BCKGRD METER/RANGE/PPM                 .1/ 76/   4.63
  CO  SAMPLE METER/RANGE/PPM               23.7/ 12/  22.94
  CO  BCKGRD METER/RANGE/PPM                1.2/ 12/   1.13
  CO2 SAMPLE METER/RANGE/PCT               73.2/ 11/  .6257
  CO2 BCKGRD METER/RANGE/PCT                8.6/ 11/  .0507
  NOX SAMPLE METER/RANGE/PPM (D)             .5/ 73/  42.20
  NOX BCKGRD METER/RANGE/PPM                 .8/  2/    .80

  DILUTION FACTOR                                21.63
  HC  CONCENTRATION PPM                           8.67
  CO  CONCENTRATION PPM                          21.15
  CO2 CONCENTRATION PCT                          .5773
  NOX CONCENTRATION PPM                          40.43

  HC  MASS GRAMS                                  3.578
  CO  MASS GRAMS                                 17.682
  CO2 MASS GRAMS                               7582.98
  NOX MASS GRAMS                                 54.641
  FUEL  KG (LB)                            2.395 (  5.28)
  KW HR (HP HR)                             9.41 ( 12.62)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .380(   .283) (   .28) (CONT)     90 MM FLTR NUMBERS          P90-2        P90-
  BSCO   G/KW HR (G/HP HR)      1.879(  1.401) (  1.40)            90 MM FLTR WT. GAINS (MG)     2.378          .000
  BSNOX  G/KW HR (G/HP HR)      5.806(  4.330) (  4.33) (CONT)     PARTICULATE GRAMS/TEST              1.309
  PART.  G/KW HR (G/HP HR)       .139(   .104) (   .10)
  BSFC  KG/KW HR (LB/HP HR)      .254(   .418)
  WORK      KW HR (HP HR)        9.41(  12.62)
  BSCO2  G/KW HR (G/HP HR)      806. (   601.)
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                                 SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                            EPA  HOT TRANS  ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                    TEST  A-H1           RUN              DIESEL   2D       EM-2045-F
ENGINE MODEL  95 CUMMINS                          DATE 10/31/95   TIME                  HCR 1.80  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                      COMPUTER PROGRAM  HDT 3.4-R           H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                             CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  56219753                           DIESEL

BAROMETER 740.4 MM HG (29.15 IN HG)     CVS:  74.0°F  RH 62. PCT  AH  80.1 GR/LB        ENGINE DEW PT. 13.3°C (56.0°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)        ENGINE: RH 45. PCT  AH  9.8 G/KG ( 68.8 GR/LB)  NOX HUMIDITY C.F.  .984
                                        REFERENCE WORK  9.17 KW HR (12.30 HP HR)        DRY-TO-WET C.F.   .976

                          SAMPLE              BACKGROUND
  FORMALDEHYDE
    PPM                    .422                 .004
    MASS  MG             365.61
  ACETALDEHYDE
    PPM                    .098                 .000
    MASS  MG             125.93
  ACROLEIN
    PPM                    .005                 .000
    MASS  MG               8.91
  ACETONE
    PPM                    .022                 .005
    MASS  MG              29.71
  PROP
    PPM                    .014                 .000
    MASS  MG              24.03
  CROTONALD.
    PPM                    .026                 .000
    MASS  MG              52.81
  ISOBUTYR+MEK
    PPM                    .008                 .000
    MASS  MG              16.11
  BENZALDEHYDE
    PPM                    .004                 .000
    MASS  MG              13.91
  HEXANALDEHYDE
    PPM                    .004                 .000
    MASS  MG              11.57

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR          28.971          CROTONALD.    MG/HP-HR              4.184
              ACETALDEHYDE MG/HP-HR           9.979          ISOBUTYR+MEK  MG/HP-HR              1.277
              ACROLEIN     MG/HP-HR            .706          BENZALDEHYDE  MG/HP-HR              1.102
              ACETONE      MG/HP-HR           2.354          HEXANALDEHYDE MG/HP-HR               .917
              PROPIONALD.  MG/HP-HR           1.904
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                                    EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                      TEST  A-H2            RUN              DIESEL   2D       EM-2045-F
ENGINE MODEL  95 CUMMINS                            DATE 10/31/95   TIME                   HCR 1.80  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                        COMPUTER PROGRAM  HDT 3.4-R            H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                               CELL  7      BAG CART 1                ENGINE OIL
ENGINE SERIAL  56219753                             DIESEL

BAROMETER 748.3 MM HG (29.46 IN HG)      CVS:  75.0°F  RH 59. PCT  AH  77.4 GR/LB          ENGINE DEW PT. 13.8°C (56.9°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)         ENGINE: RH 47. PCT  AH 10.1 G/KG ( 70.4 GR/LB)    NOX HUMIDITY C.F.  .988
                                         REFERENCE WORK  9.17 KW HR (12.30 HP HR)          DRY-TO-WET C.F.   .977
BAG RESULTS
  BAG NUMBER                                        1
  TIME SECONDS                                   1207.3
  TOT. BLOWER RATE SCMM (SCFM)                34.32 (1211.9)
  TOT. 90MM RATE SCMM (SCFM)                    .07 ( 2.31)
  TOT. 20X20 RATE SCMM (SCFM)                  1.56 ( 55.2)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)             .09 ( 3.29)
  TOTAL FLOW STD. CU. METRES(SCF)             725.2 ( 25608.)

  HC  SAMPLE METER/RANGE/PPM                    .2/ 76/  13.30
  HC  BCKGRD METER/RANGE/PPM                    .1/ 76/   4.91
  CO  SAMPLE METER/RANGE/PPM                  27.6/ 12/  26.79
  CO  BCKGRD METER/RANGE/PPM                   6.3/ 12/   5.99
  CO2 SAMPLE METER/RANGE/PCT                  72.9/ 11/  .6221
  CO2 BCKGRD METER/RANGE/PCT                   8.6/ 11/  .0507
  NOX SAMPLE METER/RANGE/PPM (D)                .5/ 73/  41.02
  NOX BCKGRD METER/RANGE/PPM                    .7/  2/    .70

  DILUTION FACTOR                                  21.74
  HC  CONCENTRATION PPM                             8.62
  CO  CONCENTRATION PPM                            20.36
  CO2 CONCENTRATION PCT                            .5737
  NOX CONCENTRATION PPM                            39.40

  HC  MASS GRAMS                                    3.589
  CO  MASS GRAMS                                   17.192
  CO2 MASS GRAMS                                 7611.36
  NOX MASS GRAMS                                   53.999
  FUEL  KG (LB)                               2.403 (  5.30)
  KW HR (HP HR)                                9.23 ( 12.38)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .389(   .290) (   .29) (CONT)      90 MM FLTR NUMBERS          P90-3       P90-
  BSCO   G/KW HR (G/HP HR)       1.862(  1.389) (  1.39)             90 MM FLTR WT. GAINS (MG)     2.318          .000
  BSNOX  G/KW HR (G/HP HR)       5.849(  4.362) (  4.36) (CONT)      PARTICULATE GRAMS/TEST               1.275
  PART.  G/KW HR (G/HP HR)        .138(   .103) (   .10)
  BSFC  KG/KW HR (LB/HP HR)       .260(   .428)
  WORK      KW HR (HP HR)         9.23(  12.38)
  BSCO2  G/KW HR (G/HP HR)        824. (   615.)
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                                           EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                  TEST  AC-C1          RUN                DIESEL   2D        EM-2045-F
ENGINE MODEL  95 CUMMINS                        DATE 11/ 3/95    TIME                   HCR 1.80  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6                   COMPUTER PROGRAM  HDT 3.4-R             H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                           CELL  7      BAG CART 1                 ENGINE OIL
ENGINE SERIAL  56219753                         DIESEL                                  CATALYST

BAROMETER 747.5 MM HG (29.43 IN HG)     CVS:  71.0°F  RH 24. PCT  AH  27.4 GR/LB        ENGINE DEW PT. 12.9°C (55.3°F)
ENGINE AIR TEMP. 23.3°C (74.0°F)        ENGINE: RH 52. PCT  AH  9.5 G/KG ( 66.4 GR/LB)  NOX HUMIDITY C.F.  .978
                                        REFERENCE WORK  9.10 KW HR (12.21 HP HR)        DRY-TO-WET C.F.   .988
BAG RESULTS
  BAG NUMBER                                     1
  TIME SECONDS                                1207.3
  TOT. BLOWER RATE SCMM (SCFM)             34.50 (1218.3)
  TOT. 90MM RATE SCMM (SCFM)                 .06 ( 2.25)
  TOT. 20X20 RATE SCMM (SCFM)               1.56 ( 55.0)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)          .09 ( 3.27)
  TOTAL FLOW STD. CU. METRES(SCF)          728.8 ( 25732.)

  HC  SAMPLE METER/RANGE/PPM                 .2/ 76/  14.50
  HC  BCKGRD METER/RANGE/PPM                 .1/ 76/   4.68
  CO  SAMPLE METER/RANGE/PPM               31.7/ 12/  30.85
  CO  BCKGRD METER/RANGE/PPM                 .1/ 12/    .09
  CO2 SAMPLE METER/RANGE/PCT               73.6/ 11/  .6305
  CO2 BCKGRD METER/RANGE/PCT                8.3/ 11/  .0489
  NOX SAMPLE METER/RANGE/PPM (D)             .5/ 73/  42.21
  NOX BCKGRD METER/RANGE/PPM                 .6/  2/    .60

  DILUTION FACTOR                                21.44
  HC  CONCENTRATION PPM                          10.04
  CO  CONCENTRATION PPM                          30.16
  CO2 CONCENTRATION PCT                          .5839
  NOX CONCENTRATION PPM                          41.13

  HC  MASS GRAMS                                 4.202
  CO  MASS GRAMS                                25.584
  CO2 MASS GRAMS                              7784.24
  NOX MASS GRAMS                                56.075
  FUEL  KG (LB)                            2.462 (  5.43)
  KW HR (HP HR)                             9.38 ( 12.58)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .448(   .334) (   .33) (CONT)     90 MM FLTR NUMBERS         2087.0-31   P90-
  BSCO   G/KW HR (G/HP HR)      2.727(  2.034) (  2.03)            90 MM FLTR WT. GAINS (MG)     1.716          .000
  BSNOX  G/KW HR (G/HP HR)      5.978(  4.457) (  4.46) (CONT)     PARTICULATE GRAMS/TEST                 .975
  PART.  G/KW HR (G/HP HR)       .104(   .078) (   .08)
  BSFC  KG/KW HR (LB/HP HR)      .262(   .432)
  WORK      KW HR (HP HR)        9.38(  12.58)
  BSCO2  G/KW HR (G/HP HR)      830. (   619.)
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                    SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                              EPA  COLD TRANS ENGINE EMISSION RESULTS         PROJECT NO. 08-7507-001

ENGINE  NUMBER                                  TEST  AC-C1          RUN              DIESEL   2D        EM-2045-F
ENGINE MODEL  95 CUMMINS                        DATE 11/ 3/95   TIME                  HCR 1.80  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6                   COMPUTER PROGRAM  HDT 3.4-R           H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                           CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  56219753                         DIESEL                                CATALYST

BAROMETER 747.5 MM HG (29.43 IN HG)    CVS:  71.0°F  RH 24. PCT  AH  27.4 GR/LB       ENGINE DEW PT. 12.9°C (55.3°F)
ENGINE AIR TEMP. 23.3°C (74.0°F)       ENGINE: RH 52. PCT  AH  9.5 G/KG ( 66.4 GR/LB) NOX HUMIDITY C.F.  .978
                                       REFERENCE WORK  9.10 KW HR (12.21 HP HR)       DRY-TO-WET C.F.   .988

                          SAMPLE              BACKGROUND
  FORMALDEHYDE
    PPM                    .928                 .004
    MASS  MG             830.92
  ACETALDEHYDE
    PPM                    .297                 .002
    MASS  MG             390.03
  ACROLEIN
    PPM                    .024                 .000
    MASS  MG              40.33
  ACETONE
    PPM                    .073                 .002
    MASS  MG             124.11
  PROPIONALDEHYDE
    PPM                    .037                 .000
    MASS  MG              64.79
  CROTONALDEHYDE
    PPM                    .045                 .000
    MASS  MG              95.17
  ISOBUTYR+MEK
    PPM                    .023                 .000
    MASS  MG              49.09
  BENZALDEHYDE
    PPM                    .007                 .000
    MASS  MG              22.11
  HEXANALDEHYDE
    PPM                    .004                 .000
    MASS  MG              11.93

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR          66.051         CROTONALD.     MG/HP-HR            7.565
              ACETALDEHYDE MG/HP-HR          31.004         ISOBUTYR+MEK   MG/HP-HR            3.902
              ACROLEIN     MG/HP-HR           3.206         BENZALDEHYDE   MG/HP-HR            1.758
              ACETONE      MG/HP-HR           9.866         HEXANALDEHYDE  MG/HP-HR             .948
              PROPIONALD.  MG/HP-HR           5.150
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                                                EPA  HOT TRANS  ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                  TEST  AC-H1           RUN                 DIESEL   2D        EM-2045-F
ENGINE MODEL  95 CUMMINS                        DATE 11/ 3/95   TIME                      HCR 1.80  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6                   COMPUTER PROGRAM  HDT 3.4-R               H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                           CELL  7      BAG CART 1                   ENGINE OIL
ENGINE SERIAL  56219753                         DIESEL                                    CATALYST

BAROMETER 747.5 MM HG (29.43 IN HG)      CVS:  72.0°F  RH 22. PCT  AH  25.8 GR/LB         ENGINE DEW PT. 12.9°C (55.2°F)
ENGINE AIR TEMP. 24.4°C (76.0°F)         ENGINE: RH 48. PCT  AH  9.5 G/KG ( 66.2 GR/LB)   NOX HUMIDITY C.F.  .978
                                         REFERENCE WORK  9.10 KW HR (12.21 HP HR)         DRY-TO-WET C.F.   .989
BAG RESULTS
  BAG NUMBER                                    1
  TIME SECONDS                               1207.5
  TOT. BLOWER RATE SCMM (SCFM)             34.88 (1231.6)
  TOT. 90MM RATE SCMM (SCFM)                 .07 ( 2.30)
  TOT. 20X20 RATE SCMM (SCFM)               1.55 ( 54.7)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)          .09 ( 3.33)
  TOTAL FLOW STD. CU. METRES(SCF)          736.4 ( 26001.)

  HC  SAMPLE METER/RANGE/PPM                 .1/ 76/  11.85
  HC  BCKGRD METER/RANGE/PPM                 .1/ 76/   4.85
  CO  SAMPLE METER/RANGE/PPM               20.4/ 12/  19.70
  CO  BCKGRD METER/RANGE/PPM                 .2/ 12/    .19
  CO2 SAMPLE METER/RANGE/PCT               71.7/ 11/  .6078
  CO2 BCKGRD METER/RANGE/PCT                8.3/ 11/  .0489
  NOX SAMPLE METER/RANGE/PPM (D)             .5/ 73/  39.57
  NOX BCKGRD METER/RANGE/PPM                1.0/  2/   1.00

  DILUTION FACTOR                                22.28
  HC  CONCENTRATION PPM                           7.22
  CO  CONCENTRATION PPM                          19.15
  CO2 CONCENTRATION PCT                          .5611
  NOX CONCENTRATION PPM                          38.16

  HC  MASS GRAMS                                 3.053
  CO  MASS GRAMS                                16.418
  CO2 MASS GRAMS                              7559.09
  NOX MASS GRAMS                                52.538
  FUEL  KG (LB)                            2.386 (  5.26)
  KW HR (HP HR)                             9.28 ( 12.44)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .329(   .245) (   .25) (CONT)      90 MM FLTR NUMBERS           2088.0-32   P90-
  BSCO   G/KW HR (G/HP HR)      1.770(  1.320) (  1.32)             90 MM FLTR WT. GAINS (MG)      1.566          .000
  BSNOX  G/KW HR (G/HP HR)      5.664(  4.223) (  4.22) (CONT)      PARTICULATE GRAMS/TEST                    .879
  PART.  G/KW HR (G/HP HR)       .095(   .071) (   .07)
  BSFC  KG/KW HR (LB/HP HR)      .257(   .423)
  WORK     KW HR (HP HR)         9.28(  12.44)
  BSCO2  G/KW HR (G/HP HR)      815. (   608.)
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                         SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                   EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                           TEST  AC-H1          RUN                DIESEL   2D       EM-2045-F
ENGINE MODEL  95 CUMMINS                 DATE 11/ 3/95   TIME                    HCR 1.80  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6             COMPUTER PROGRAM  HDT 3.4-R             H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                    CELL  7      BAG CART 1                 ENGINE OIL
ENGINE SERIAL  56219753                  DIESEL                                  CATALYST

BAROMETER 747.5 MM HG (29.43 IN HG)   CVS:  72.0°F  RH 22. PCT  AH  25.8 GR/LB      ENGINE DEW PT. 12.9°C (55.2°F)
ENGINE AIR TEMP. 24.4°C (76.0°F)      ENGINE: RH 48. PCT  AH  9.5 G/KG ( 66.2 GR/LB) NOX HUMIDITY C.F.  .978
                                      REFERENCE WORK  9.10 KW HR (12.21 HP HR)       DRY-TO-WET C.F.   .989

                      SAMPLE              BACKGROUND
 FORMALDEHYDE
   PPM                   .571                .003
   MASS  MG            515.78
 ACETALDEHYDE
   PPM                   .180                .002
   MASS  MG            237.42
 ACROLEIN
   PPM                   .007                .000
   MASS  MG             11.30
 ACETONE
   PPM                   .042                .002
   MASS  MG             70.72
 PROP
   PPM                   .022                .000
   MASS  MG             38.63
 CROTONALD.
   PPM                   .024                .000
   MASS  MG             49.91
 ISOBUTYR+MEK
   PPM                   .011                .000
   MASS  MG             24.87
 BENZALDEHYDE
   PPM                   .003                .000
   MASS  MG              8.68
 HEXANALDEHYDE
   PPM                   .003                .000
   MASS  MG              8.21

TOTAL RESULTS
           FORMALDEHYDE MG/HP-HR          41.462        CROTONALD.    MG/HP-HR           4.012
           ACETALDEHYDE MG/HP-HR          19.085        ISOBUTYR+MEK  MG/HP-HR           1.999
           ACROLEIN     MG/HP-HR            .909        BENZALDEHYDE  MG/HP-HR            .698
           ACETONE      MG/HP-HR           5.685        HEXANALDEHYDE MG/HP-HR            .660
           PROPIONALD.  MG/HP-HR           3.105
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                                          EPA  HOT TRANS  ENGINE EMISSION RESULTS            PROJECT NO. 08-7507-001

ENGINE  NUMBER                                  TEST  AC-H2           RUN                DIESEL   2D       EM-2045-F
ENGINE MODEL  95 CUMMINS                        DATE 11/ 3/95   TIME                     HCR 1.80  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                    COMPUTER PROGRAM  HDT 3.4-R              H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                           CELL  7      BAG CART 1                  ENGINE OIL
ENGINE SERIAL  56219753                         DIESEL                                   CATALYST

BAROMETER 747.5 MM HG (29.43 IN HG)      CVS:  72.0°F  RH 22. PCT  AH  25.8 GR/LB        ENGINE DEW PT. 12.9°C (55.3°F)
ENGINE AIR TEMP. 24.4°C (76.0°F)         ENGINE: RH 49. PCT  AH  9.5 G/KG ( 66.4 GR/LB)  NOX HUMIDITY C.F.  .978
                                         REFERENCE WORK  9.10 KW HR (12.21 HP HR)        DRY-TO-WET C.F.   .989
BAG RESULTS
  BAG NUMBER                                     1
  TIME SECONDS                                1207.6
  TOT. BLOWER RATE SCMM (SCFM)              34.98 (1235.1)
  TOT. 90MM RATE SCMM (SCFM)                  .07 ( 2.30)
  TOT. 20X20 RATE SCMM (SCFM)                1.54 ( 54.5)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)           .09 ( 3.35)
  TOTAL FLOW STD. CU. METRES(SCF)           738.3 ( 26069.)

  HC  SAMPLE METER/RANGE/PPM                 .1/ 76/  10.22
  HC  BCKGRD METER/RANGE/PPM                 .0/ 76/   3.51
  CO  SAMPLE METER/RANGE/PPM               19.9/ 12/  19.21
  CO  BCKGRD METER/RANGE/PPM                 .1/ 12/    .09
  CO2 SAMPLE METER/RANGE/PCT               70.6/ 11/  .5949
  CO2 BCKGRD METER/RANGE/PCT                8.1/ 11/  .0476
  NOX SAMPLE METER/RANGE/PPM (D)             .5/ 73/  38.71
  NOX BCKGRD METER/RANGE/PPM                 .6/  2/    .60

  DILUTION FACTOR                                22.77
  HC  CONCENTRATION PPM                           6.86
  CO  CONCENTRATION PPM                          18.76
  CO2 CONCENTRATION PCT                          .5494
  NOX CONCENTRATION PPM                          37.70

  HC  MASS GRAMS                                 2.911
  CO  MASS GRAMS                                16.128
  CO2 MASS GRAMS                               7419.77
  NOX MASS GRAMS                                52.068
  FUEL  KG (LB)                             2.342 (  5.16)
  KW HR (HP HR)                              9.22 ( 12.37)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .316(   .235) (   .24) (CONT)     90 MM FLTR NUMBERS          2089.0-33   P90-
  BSCO   G/KW HR (G/HP HR)       1.748(  1.304) (  1.30)            90 MM FLTR WT. GAINS (MG)     1.609          .000
  BSNOX  G/KW HR (G/HP HR)       5.645(  4.209) (  4.21) (CONT)     PARTICULATE GRAMS/TEST                   .904
  PART.  G/KW HR (G/HP HR)        .098(   .073) (   .07)
  BSFC  KG/KW HR (LB/HP HR)       .254(   .417)
  WORK     KW HR (HP HR)          9.22(  12.37)
  BSCO2  G/KW HR (G/HP HR)        804. (   600.)
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                                         EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                     TEST  A-C3           RUN             DIESEL   2D        EM-2045-F
ENGINE MODEL  95 CUMMINS                           DATE 11/ 8/95   TIME 8:58            HCR 1.80  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                       COMPUTER PROGRAM  HDT 3.4-R          H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                              CELL  7      BAG CART 1              ENGINE OIL
ENGINE SERIAL  56219753                            DIESEL

BAROMETER 748.0 MM HG (29.45 IN HG)       CVS:  74.0°F  RH 30. PCT  AH  38.2 GR/LB      ENGINE DEW PT. 12.9°C (55.2°F)
ENGINE AIR TEMP. 25.0°C (77.0°F)          ENGINE: RH 47. PCT  AH  9.4 G/KG ( 66.1 GR/LB) NOX HUMIDITY C.F.  .977
                                          REFERENCE WORK  9.18 KW HR (12.31 HP HR)      DRY-TO-WET C.F.   .985
BAG RESULTS
  BAG NUMBER                                     1
  TIME SECONDS                                1207.7
  TOT. BLOWER RATE SCMM (SCFM)             33.98 (1199.9)
  TOT. 90MM RATE SCMM (SCFM)                 .07 ( 2.31)
  TOT. 20X20 RATE SCMM (SCFM)               1.57 ( 55.5)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)          .09 ( 3.22)
  TOTAL FLOW STD. CU. METRES(SCF)          718.8 ( 25380.)

  HC  SAMPLE METER/RANGE/PPM                .2/ 76/  14.30
  HC  BCKGRD METER/RANGE/PPM                .0/ 76/   3.79
  CO  SAMPLE METER/RANGE/PPM              31.9/ 12/  31.05
  CO  BCKGRD METER/RANGE/PPM                .7/ 12/    .66
  CO2 SAMPLE METER/RANGE/PCT              75.4/ 11/  .6523
  CO2 BCKGRD METER/RANGE/PCT               8.6/ 11/  .0507
  NOX SAMPLE METER/RANGE/PPM (D)            .5/ 73/  43.12
  NOX BCKGRD METER/RANGE/PPM                .2/  2/    .20

  DILUTION FACTOR                                20.72
  HC  CONCENTRATION PPM                          10.69
  CO  CONCENTRATION PPM                          29.74
  CO2 CONCENTRATION PCT                          .6040
  NOX CONCENTRATION PPM                          42.30

  HC  MASS GRAMS                                  4.415
  CO  MASS GRAMS                                 24.888
  CO2 MASS GRAMS                               7942.88
  NOX MASS GRAMS                                 56.834
  FUEL  KG (LB)                            2.512 (  5.54)
  KW HR (HP HR)                             9.19 ( 12.33)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .480(   .358) (   .36) (CONT)      90 MM FLTR NUMBERS          2244.0-46   P90-
  BSCO   G/KW HR (G/HP HR)       2.707(  2.018) (  2.02)             90 MM FLTR WT. GAINS (MG)      2.702          .000
  BSNOX  G/KW HR (G/HP HR)       6.181(  4.609) (  4.61) (CONT)      PARTICULATE GRAMS/TEST              1.475
  PART.  G/KW HR (G/HP HR)        .160(   .120) (   .12)
  BSFC  KG/KW HR (LB/HP HR)       .273(   .449)
  WORK     KW HR (HP HR)         9.19(  12.33)
  BSCO2  G/KW HR (G/HP HR)       864. (   644.)
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                                            EPA  COLD TRANS ENGINE EMISSION RESULTS            PROJECT NO. 08-7507-001

ENGINE  NUMBER                                 TEST  A-C3           RUN                     DIESEL   2D       EM-2045-F
ENGINE MODEL  95 CUMMINS                       DATE 11/ 8/95   TIME 8:58                    HCR 1.80  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6                  COMPUTER PROGRAM  HDT 3.4-R                  H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                          CELL  7      BAG CART 1                      ENGINE OIL
ENGINE SERIAL  56219753                        DIESEL

BAROMETER 748.0 MM HG (29.45 IN HG)     CVS:  74.0°F  RH 30. PCT  AH  38.2 GR/LB            ENGINE DEW PT. 12.9°C (55.2°F)
ENGINE AIR TEMP. 25.0°C (77.0°F)        ENGINE: RH 47. PCT  AH  9.4 G/KG ( 66.1 GR/LB)      NOX HUMIDITY C.F.  .977
                                        REFERENCE WORK  9.18 KW HR (12.31 HP HR)            DRY-TO-WET C.F.   .985

                          SAMPLE            BACKGROUND
  FORMALDEHYDE
    PPM                     .669              .000
    MASS  MG              592.19
  ACETALDEHYDE
    PPM                     .172              .000
    MASS  MG              223.84
  ACROLEIN
    PPM                     .013              .000
    MASS  MG               22.07
  ACETONE
    PPM                     .047              .003
    MASS  MG               76.34
  PROPIONALDEHYDE
    PPM                     .032              .000
    MASS  MG               54.29
  CROTONALDEHYDE
    PPM                     .045              .000
    MASS  MG               93.80
  ISOBUTYR+MEK
    PPM                     .017              .000
    MASS  MG               36.10
  BENZALDEHYDE
    PPM                     .007              .000
    MASS  MG               22.32
  HEXANALDEHYDE
    PPM                     .009              .000
    MASS  MG               25.35

TOTAL RESULTS
            FORMALDEHYDE MG/HP-HR          48.028          CROTONALD.    MG/HP-HR            7.607
            ACETALDEHYDE MG/HP-HR          18.154          ISOBUTYR+MEK  MG/HP-HR            2.928
            ACROLEIN     MG/HP-HR           1.790          BENZALDEHYDE  MG/HP-HR            1.810
            ACETONE      MG/HP-HR           6.191          HEXANALDEHYDE MG/HP-HR            2.056
            PROPIONALD.  MG/HP-HR           4.403
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                                 EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                   TEST  A-H5           RUN             DIESEL   2D        EM-2045-F
ENGINE MODEL  95 CUMMINS                         DATE 11/ 8/95   TIME 9:38            HCR 1.80  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                     COMPUTER PROGRAM  HDT 3.4-R          H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                            CELL  7      BAG CART 1              ENGINE OIL
ENGINE SERIAL  56219753                          DIESEL

BAROMETER 748.5 MM HG (29.47 IN HG)      CVS:  75.0°F  RH 28. PCT  AH  36.5 GR/LB      ENGINE DEW PT. 13.3°C (55.9°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)         ENGINE: RH 45. PCT  AH  9.7 G/KG ( 67.8 GR/LB) NOX HUMIDITY C.F.  .982
                                         REFERENCE WORK  9.18 KW HR (12.31 HP HR)       DRY-TO-WET C.F.   .986
BAG RESULTS
  BAG NUMBER                                      1
  TIME SECONDS                                 1207.2
  TOT. BLOWER RATE SCMM (SCFM)              34.05 (1202.4)
  TOT. 90MM RATE SCMM (SCFM)                  .07 ( 2.33)
  TOT. 20X20 RATE SCMM (SCFM)                1.55 ( 54.7)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)           .09 ( 3.24)
  TOTAL FLOW STD. CU. METRES(SCF)           719.4 ( 25404.)

  HC  SAMPLE METER/RANGE/PPM                  .1/ 76/  12.15
  HC  BCKGRD METER/RANGE/PPM                  .0/ 76/   3.83
  CO  SAMPLE METER/RANGE/PPM                23.0/ 12/  22.25
  CO  BCKGRD METER/RANGE/PPM                  .6/ 12/    .57
  CO2 SAMPLE METER/RANGE/PCT                74.2/ 11/  .6377
  CO2 BCKGRD METER/RANGE/PCT                 8.4/ 11/  .0495
  NOX SAMPLE METER/RANGE/PPM (D)              .5/ 73/  40.41
  NOX BCKGRD METER/RANGE/PPM                  .4/  2/    .40

  DILUTION FACTOR                                21.23
  HC  CONCENTRATION PPM                           8.50
  CO  CONCENTRATION PPM                          21.25
  CO2 CONCENTRATION PCT                          .5906
  NOX CONCENTRATION PPM                          39.46

  HC  MASS GRAMS                                 3.513
  CO  MASS GRAMS                                17.798
  CO2 MASS GRAMS                               7772.63
  NOX MASS GRAMS                                53.295
  FUEL  KG (LB)                             2.454 (  5.41)
  KW HR (HP HR)                              9.12 ( 12.23)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .385(   .287) (   .29) (CONT)     90 MM FLTR NUMBERS          2397.0-47   P90-
  BSCO   G/KW HR (G/HP HR)       1.952(  1.455) (  1.46)            90 MM FLTR WT. GAINS (MG)     2.321          .000
  BSNOX  G/KW HR (G/HP HR)       5.844(  4.358) (  4.36) (CONT)     PARTICULATE GRAMS/TEST              1.259
  PART.  G/KW HR (G/HP HR)        .138(   .103) (   .10)
  BSFC  KG/KW HR (LB/HP HR)       .269(   .442)
  WORK      KW HR (HP HR)         9.12(  12.23)
  BSCO2  G/KW HR (G/HP HR)       852. (   636.)
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                                   EPA  HOT TRANS  ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                    TEST  A-H5           RUN            DIESEL   2D        EM-2045-F
ENGINE MODEL  95 CUMMINS                          DATE 11/ 8/95   TIME 9:38           HCR 1.80  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                      COMPUTER PROGRAM  HDT 3.4-R         H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                             CELL  7      BAG CART 1             ENGINE OIL
ENGINE SERIAL  56219753                           DIESEL

BAROMETER 748.5 MM HG (29.47 IN HG)     CVS:  75.0°F  RH 28. PCT  AH  36.5 GR/LB          ENGINE DEW PT. 13.3°C (55.9°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)        ENGINE: RH 45. PCT  AH  9.7 G/KG ( 67.8 GR/LB)  NOX HUMIDITY C.F.  .982
                                        REFERENCE WORK  9.18 KW HR (12.31 HP HR)         DRY-TO-WET C.F.   .986

                          SAMPLE               BACKGROUND
  FORMALDEHYDE
    PPM                    .424                  .000
    MASS  MG             375.83
  ACETALDEHYDE
    PPM                    .110                  .000
    MASS  MG             143.32
  ACROLEIN
    PPM                    .008                  .000
    MASS  MG              13.90
  ACETONE
    PPM                    .029                  .003
    MASS  MG              44.97
  PROP
    PPM                    .018                  .000
    MASS  MG              31.02
  CROTONALD.
    PPM                    .030                  .000
    MASS  MG              61.30
  ISOBUTYR+MEK
    PPM                    .010                  .000
    MASS  MG              21.67
  BENZALDEHYDE
    PPM                    .005                  .000
    MASS  MG              14.56
  HEXANALDEHYDE
    PPM                    .005                  .000
    MASS  MG              13.97

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR             30.730          CROTONALD.    MG/HP-HR             5.012
              ACETALDEHYDE MG/HP-HR             11.719          ISOBUTYR+MEK  MG/HP-HR             1.772
              ACROLEIN     MG/HP-HR              1.137          BENZALDEHYDE  MG/HP-HR             1.190
              ACETONE      MG/HP-HR              3.677          HEXANALDEHYDE MG/HP-HR             1.143
              PROPIONALD.  MG/HP-HR              2.536
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ENGINE  NUMBER                                    TEST  A-H6            RUN              DIESEL   2D        EM-2045-F
ENGINE MODEL  95 CUMMINS                          DATE 11/ 8/95   TIME 10:18             HCR 1.80  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6                     COMPUTER PROGRAM  HDT 3.4-R            H .131  C .869  O .000  X .000
ENGINE CYCLE   DIESEL                             CELL  7      BAG CART 1                ENGINE OIL
ENGINE SERIAL  56219753                           DIESEL

BAROMETER 748.3 MM HG (29.46 IN HG)      CVS:  74.0°F  RH 33. PCT  AH  42.3 GR/LB        ENGINE DEW PT. 13.4°C (56.1°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)         ENGINE: RH 44. PCT  AH  9.8 G/KG ( 68.3 GR/LB)  NOX HUMIDITY C.F.  .983
                                         REFERENCE WORK  9.18 KW HR (12.31 HP HR)        DRY-TO-WET C.F.   .985
BAG RESULTS
  BAG NUMBER                                  1
  TIME SECONDS                             1207.1
  TOT. BLOWER RATE SCMM (SCFM)           34.24 (1208.9)
  TOT. 90MM RATE SCMM (SCFM)               .07 ( 2.30)
  TOT. 20X20 RATE SCMM (SCFM)             1.56 ( 55.1)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)        .09 ( 3.24)
  TOTAL FLOW STD. CU. METRES(SCF)        723.3 ( 25540.)

  HC  SAMPLE METER/RANGE/PPM               .1/ 76/  12.34
  HC  BCKGRD METER/RANGE/PPM               .0/ 76/   3.83
  CO  SAMPLE METER/RANGE/PPM             22.7/ 12/  21.96
  CO  BCKGRD METER/RANGE/PPM               .1/ 12/    .09
  CO2 SAMPLE METER/RANGE/PCT             73.4/ 11/  .6281
  CO2 BCKGRD METER/RANGE/PCT              8.4/ 11/  .0495
  NOX SAMPLE METER/RANGE/PPM (D)           .5/ 73/  40.12
  NOX BCKGRD METER/RANGE/PPM               .4/  2/    .40

  DILUTION FACTOR                            21.56
  HC  CONCENTRATION PPM                       8.69
  CO  CONCENTRATION PPM                      21.37
  CO2 CONCENTRATION PCT                      .5809
  NOX CONCENTRATION PPM                      39.12

  HC  MASS GRAMS                              3.610
  CO  MASS GRAMS                             17.996
  CO2 MASS GRAMS                           7686.34
  NOX MASS GRAMS                             53.197
  FUEL  KG (LB)                          2.427 (  5.35)
  KW HR (HP HR)                           9.07 ( 12.16)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .398(   .297) (   .30) (CONT)     90 MM FLTR NUMBERS          2423.0-66   P90-
  BSCO   G/KW HR (G/HP HR)       1.985(  1.480) (  1.48)            90 MM FLTR WT. GAINS (MG)     2.334           .000
  BSNOX  G/KW HR (G/HP HR)       5.867(  4.375) (  4.37) (CONT)     PARTICULATE GRAMS/TEST               1.289
  PART.  G/KW HR (G/HP HR)        .142(   .106) (   .11)
  BSFC  KG/KW HR (LB/HP HR)       .268(   .440)
  WORK     KW HR (HP HR)          9.07(  12.16)
  BSCO2  G/KW HR (G/HP HR)       848. (   632.)
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                                                    EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                 TEST  B-C1           RUN                 DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                       DATE 11/ 9/95   TIME 9:30                HCR 1.90  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6                  COMPUTER PROGRAM  HDT 3.4-R              H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                          CELL  7      BAG CART 1                  ENGINE OIL
ENGINE SERIAL  6B7AA5.9                        NEAT REE

BAROMETER 738.9 MM HG (29.09 IN HG)     CVS:  77.0°F  RH 43. PCT  AH  60.6 GR/LB        ENGINE DEW PT. 13.8°C (56.8°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)        ENGINE: RH 47. PCT  AH 10.1 G/KG ( 71.0 GR/LB)  NOX HUMIDITY C.F.  .990
                                        REFERENCE WORK  8.76 KW HR (11.75 HP HR)        DRY-TO-WET C.F.   .980
BAG RESULTS
  BAG NUMBER                                    1
  TIME SECONDS                               1207.3
  TOT. BLOWER RATE SCMM (SCFM)             33.55 (1184.7)
  TOT. 90MM RATE SCMM (SCFM)                 .06 ( 2.26)
  TOT. 20X20 RATE SCMM (SCFM)               1.56 ( 55.0)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)          .09 ( 3.00)
  TOTAL FLOW STD. CU. METRES(SCF)          709.4 ( 25051.)

  HC  SAMPLE METER/RANGE/PPM                .1/ 76/   7.74
  HC  BCKGRD METER/RANGE/PPM                .0/ 76/   4.07
  CO  SAMPLE METER/RANGE/PPM              17.9/ 12/  17.25
  CO  BCKGRD METER/RANGE/PPM                .2/ 12/    .19
  CO2 SAMPLE METER/RANGE/PCT              75.5/ 11/  .6536
  CO2 BCKGRD METER/RANGE/PCT               8.6/ 11/  .0507
  NOX SAMPLE METER/RANGE/PPM (D)            .5/ 73/  39.38
  NOX BCKGRD METER/RANGE/PPM                .5/  2/    .50

  DILUTION FACTOR                               20.83
  HC  CONCENTRATION PPM                          3.87
  CO  CONCENTRATION PPM                         16.61
  CO2 CONCENTRATION PCT                         .6053
  NOX CONCENTRATION PPM                         38.12

  HC  MASS GRAMS                                1.762
  CO  MASS GRAMS                               13.720
  CO2 MASS GRAMS                              7855.49
  NOX MASS GRAMS                               51.184
  FUEL  KG (LB)                            2.769 (  6.11)
  KW HR (HP HR)                             8.80 ( 11.80)

TOTAL RESULTS
  BSHC    G/KW HR (G/HP HR)       .200(   .149) (   .15) (CONT)     90 MM FLTR NUMBERS          2224.0-67   P90-
  BSCO    G/KW HR (G/HP HR)      1.559(  1.163) (  1.16)            90 MM FLTR WT. GAINS (MG)      2.275            .000
  BSNOX   G/KW HR (G/HP HR)      5.817(  4.338) (  4.34) (CONT)     PARTICULATE GRAMS/TEST                  1.254
  PART.   G/KW HR (G/HP HR)       .143(   .106) (   .11)
  BSFC  KG/KW HR (LB/HP HR)       .315(   .517)
  WORK       KW HR (HP HR)        8.80(  11.80)
  BSCO2   G/KW HR (G/HP HR)      893. (   666.)
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                           SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                    EPA  COLD TRANS ENGINE EMISSION RESULTS            PROJECT NO. 08-7507-001

ENGINE  NUMBER                                   TEST  B-C1            RUN            DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                         DATE 11/ 9/95   TIME 9:30            HCR 1.90  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                     COMPUTER PROGRAM  HDT 3.4-R          H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                            CELL  7      BAG CART 1              ENGINE OIL
ENGINE SERIAL  6B7AA5.9                          NEAT REE

BAROMETER 738.9 MM HG (29.09 IN HG)      CVS:  77.0°F  RH 43. PCT  AH  60.6 GR/LB         ENGINE DEW PT. 13.8°C (56.8°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)         ENGINE: RH 47. PCT  AH 10.1 G/KG ( 71.0 GR/LB)  NOX HUMIDITY C.F.  .990
                                         REFERENCE WORK  8.76 KW HR (11.75 HP HR)        DRY-TO-WET C.F.   .980

                            SAMPLE               BACKGROUND
  FORMALDEHYDE
    PPM                       .382                  .003
    MASS  MG                329.37
  ACETALDEHYDE
    PPM                       .100                  .001
    MASS  MG                126.96
  ACROLEIN
    PPM                       .015                  .000
    MASS  MG                 24.81
  ACETONE
    PPM                       .002                  .000
    MASS  MG                  2.72
  PROPIONALDEHYDE
    PPM                       .013                  .000
    MASS  MG                 21.68
  CROTONALDEHYDE
    PPM                       .009                  .000
    MASS  MG                 18.88
  ISOBUTYR+MEK
    PPM                       .008                  .000
    MASS  MG                 16.34
  BENZALDEHYDE
    PPM                       .002                  .000
    MASS  MG                  6.41
  HEXANALDEHYDE
    PPM                       .003                  .000
    MASS  MG                  8.47

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR           27.913          CROTONALD.     MG/HP-HR            1.600
              ACETALDEHYDE MG/HP-HR           10.760          ISOBUTYR+MEK   MG/HP-HR            1.385
              ACROLEIN     MG/HP-HR            2.103          BENZALDEHYDE   MG/HP-HR             .544
              ACETONE      MG/HP-HR             .230          HEXANALDEHYDE  MG/HP-HR             .718
              PROPIONALD.  MG/HP-HR            1.837
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                              SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                        EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                               TEST  B-H1          RUN                DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                     DATE 11/ 9/95   TIME 10:10             HCR 1.90  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                 COMPUTER PROGRAM  HDT 3.4-R            H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                        CELL  7      BAG CART 1                ENGINE OIL
ENGINE SERIAL  6B7AA5.9                      NEAT REE

BAROMETER 741.9 MM HG (29.21 IN HG)    CVS:  77.0°F  RH 42. PCT   AH  60.2 GR/LB        ENGINE DEW PT. 13.7°C (56.6°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)       ENGINE: RH 43. PCT  AH 10.0 G/KG ( 70.2 GR/LB)  NOX HUMIDITY C.F.  .988
                                       REFERENCE WORK  8.76 KW HR (11.75 HP HR)        DRY-TO-WET C.F.    .980

BAG RESULTS
  BAG NUMBER                                  1
  TIME SECONDS                             1207.4
  TOT. BLOWER RATE SCMM (SCFM)           33.86 (1195.7)
  TOT. 90MM RATE SCMM (SCFM)               .06 ( 2.27)
  TOT. 20X20 RATE SCMM (SCFM)             1.54 ( 54.5)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)        .08 ( 2.99)
  TOTAL FLOW STD. CU. METRES(SCF)        715.5 ( 25265.)

  HC  SAMPLE METER/RANGE/PPM              .1/ 76/   6.64
  HC  BCKGRD METER/RANGE/PPM              .0/ 76/   4.04
  CO  SAMPLE METER/RANGE/PPM            13.7/ 12/  13.15
  CO  BCKGRD METER/RANGE/PPM              .4/ 12/    .38
  CO2 SAMPLE METER/RANGE/PCT            73.4/ 11/  .6281
  CO2 BCKGRD METER/RANGE/PCT             9.0/ 11/  .0532
  NOX SAMPLE METER/RANGE/PPM (D)          .5/ 73/  38.46
  NOX BCKGRD METER/RANGE/PPM              .7/  2/    .70

  DILUTION FACTOR                             21.69
  HC  CONCENTRATION PPM                        2.79
  CO  CONCENTRATION PPM                       12.45
  CO2 CONCENTRATION PCT                       .5773
  NOX CONCENTRATION PPM                       37.03

  HC  MASS GRAMS                               1.281
  CO  MASS GRAMS                              10.370
  CO2 MASS GRAMS                            7556.60
  NOX MASS GRAMS                              50.053
  FUEL  KG (LB)                          2.662 (  5.87)
  KW HR (HP HR)                           8.77 ( 11.76)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .146(   .109) (   .11) (CONT)     90 MM FLTR NUMBERS          2425.0-68   P90-
  BSCO   G/KW HR (G/HP HR)       1.182(   .882) (   .88)            90 MM FLTR WT. GAINS (MG)     1.873          .000
  BSNOX  G/KW HR (G/HP HR)       5.708(  4.256) (  4.26) (CONT)     PARTICULATE GRAMS/TEST              1.034
  PART.  G/KW HR (G/HP HR)        .118(   .088) (   .09)
  BSFC  KG/KW HR (LB/HP HR)       .304(   .499)
  WORK     KW HR (HP HR)          8.77(  11.76)
  BSCO2  G/KW HR (G/HP HR)       862. (   643.)
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                                      EPA  HOT TRANS  ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                      TEST  B-H1            RUN            DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                            DATE 11/ 9/95   TIME 10:10           HCR 1.90  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                        COMPUTER PROGRAM  HDT 3.4-R          H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                               CELL  7       BAG CART 1             ENGINE OIL
ENGINE SERIAL  6B7AA5.9                             NEAT REE

BAROMETER 741.9 MM HG (29.21 IN HG)        CVS:  77.0°F  RH 42. PCT  AH  60.2 GR/LB          ENGINE DEW PT. 13.7°C (56.6°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)           ENGINE: RH 43. PCT  AH 10.0 G/KG ( 70.2 GR/LB)   NOX HUMIDITY C.F.  .988
                                           REFERENCE WORK  8.76 KW HR (11.75 HP HR)         DRY-TO-WET C.F.   .980

                         SAMPLE               BACKGROUND
  FORMALDEHYDE
    PPM                    .265                  .003
    MASS  MG             229.69
  ACETALDEHYDE
    PPM                    .069                  .001
    MASS  MG              87.69
  ACROLEIN
    PPM                    .007                  .000
    MASS  MG              11.54
  ACETONE
    PPM                    .001                  .000
    MASS  MG               1.31
  PROP
    PPM                    .012                  .000
    MASS  MG              19.66
  CROTONALD.
    PPM                    .007                  .000
    MASS  MG              13.44
  ISOBUTYR+MEK
    PPM                    .005                  .000
    MASS  MG              11.40
  BENZALDEHYDE
    PPM                    .002                  .000
    MASS  MG               4.91
  HEXANALDEHYDE
    PPM                    .001                  .000
    MASS  MG               3.57

TOTAL RESULTS
             FORMALDEHYDE MG/HP-HR            19.532        CROTONALD.    MG/HP-HR            1.143
             ACETALDEHYDE MG/HP-HR             7.456        ISOBUTYR+MEK  MG/HP-HR             .969
             ACROLEIN     MG/HP-HR              .981        BENZALDEHYDE  MG/HP-HR             .418
             ACETONE      MG/HP-HR              .112        HEXANALDEHYDE MG/HP-HR             .304
             PROPIONALD.  MG/HP-HR             1.671
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                                    EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                  TEST  B-H2           RUN              DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                        DATE 11/ 9/95   TIME                  HCR 1.90  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                    COMPUTER PROGRAM  HDT 3.4-R           H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                           CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                         NEAT REE

BAROMETER 741.7 MM HG (29.20 IN HG)     CVS:  76.0°F  RH 45. PCT  AH  61.9 GR/LB       ENGINE DEW PT. 13.7°C (56.6°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)        ENGINE: RH 45. PCT  AH 10.0 G/KG ( 70.2 GR/LB)  NOX HUMIDITY C.F.  .988
                                        REFERENCE WORK  8.76 KW HR (11.75 HP HR)        DRY-TO-WET C.F.   .980
BAG RESULTS
  BAG NUMBER                                   1
  TIME SECONDS                              1208.0
  TOT. BLOWER RATE SCMM (SCFM)           33.97 (1199.5)
  TOT. 90MM RATE SCMM (SCFM)               .06 ( 2.27)
  TOT. 20X20 RATE SCMM (SCFM)             1.53 ( 54.1)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)        .09 ( 3.04)
  TOTAL FLOW STD. CU. METRES(SCF)        717.8 ( 25347.)

  HC  SAMPLE METER/RANGE/PPM               .1/ 76/   6.29
  HC  BCKGRD METER/RANGE/PPM               .0/ 76/   3.74
  CO  SAMPLE METER/RANGE/PPM             14.7/ 12/  14.12
  CO  BCKGRD METER/RANGE/PPM               .4/ 12/    .38
  CO2 SAMPLE METER/RANGE/PCT             72.5/ 11/  .6173
  CO2 BCKGRD METER/RANGE/PCT              8.7/ 11/  .0514
  NOX SAMPLE METER/RANGE/PPM (D)           .5/ 73/  37.79
  NOX BCKGRD METER/RANGE/PPM               .4/  2/    .40

  DILUTION FACTOR                               22.06
  HC  CONCENTRATION PPM                          2.72
  CO  CONCENTRATION PPM                         13.39
  CO2 CONCENTRATION PCT                         .5683
  NOX CONCENTRATION PPM                         36.65

  HC  MASS GRAMS                                 1.254
  CO  MASS GRAMS                                11.189
  CO2 MASS GRAMS                              7462.76
  NOX MASS GRAMS                                49.701
  FUEL  KG (LB)                          2.629 (  5.80)
  KW HR (HP HR)                           8.70 ( 11.67)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .144(   .107) (   .11) (CONT)     90 MM FLTR NUMBERS         2430.0-71   P90-
  BSCO   G/KW HR (G/HP HR)       1.286(   .959) (   .96)            90 MM FLTR WT. GAINS (MG)     1.875          .000
  BSNOX  G/KW HR (G/HP HR)       5.711(  4.259) (  4.26) (CONT)     PARTICULATE GRAMS/TEST              1.041
  PART.  G/KW HR (G/HP HR)        .120(   .089) (   .09)
  BSFC  KG/KW HR (LB/HP HR)       .302(   .497)
  WORK     KW HR (HP HR)          8.70(  11.67)
  BSCO2  G/KW HR (G/HP HR)       858. (   639.)
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                                    EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                               TEST  BC-C1          RUN              DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                     DATE 11/10/95   TIME                  HCR 1.90  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                 COMPUTER PROGRAM  HDT 3.4-R           H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                        CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                      NEAT REE                              CATALYST

BAROMETER 736.1 MM HG (28.98 IN HG)    CVS:  74.0°F  RH 62. PCT  AH  80.6 GR/LB         ENGINE DEW PT. 14.8°C (58.6°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)       ENGINE: RH 48. PCT  AH 10.9 G/KG ( 76.2 GR/LB)  NOX HUMIDITY C.F. 1.003
                                       REFERENCE WORK  8.69 KW HR (11.65 HP HR)        DRY-TO-WET C.F.   .975
BAG RESULTS
  BAG NUMBER                                 1
  TIME SECONDS                            1206.9
  TOT. BLOWER RATE SCMM (SCFM)          33.20 (1172.3)
  TOT. 90MM RATE SCMM (SCFM)              .06 ( 2.21)
  TOT. 20X20 RATE SCMM (SCFM)            1.56 ( 55.1)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)       .09 ( 3.10)
  TOTAL FLOW STD. CU. METRES(SCF)       702.2 ( 24796.)

  HC  SAMPLE METER/RANGE/PPM              .1/ 76/   6.97
  HC  BCKGRD METER/RANGE/PPM              .1/ 76/   4.60
  CO  SAMPLE METER/RANGE/PPM            14.1/ 12/  13.53
  CO  BCKGRD METER/RANGE/PPM              .4/ 12/    .38
  CO2 SAMPLE METER/RANGE/PCT            75.7/ 11/  .6560
  CO2 BCKGRD METER/RANGE/PCT             8.4/ 11/  .0495
  NOX SAMPLE METER/RANGE/PPM (D)          .5/ 73/  39.02
  NOX BCKGRD METER/RANGE/PPM              .5/  2/    .50

  DILUTION FACTOR                           20.77
  HC  CONCENTRATION PPM                      2.59
  CO  CONCENTRATION PPM                     12.74
  CO2 CONCENTRATION PCT                     .6089
  NOX CONCENTRATION PPM                     37.59

  HC  MASS GRAMS                            1.169
  CO  MASS GRAMS                           10.414
  CO2 MASS GRAMS                          7822.50
  NOX MASS GRAMS                           50.628
  FUEL  KG (LB)                         2.755 (  6.07)
  KW HR (HP HR)                          8.70 ( 11.67)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)         .134(   .100) (   .10) (CONT)     90 MM FLTR NUMBERS         2224.0-72   P90-
  BSCO   G/KW HR (G/HP HR)        1.197(   .892) (   .89)            90 MM FLTR WT. GAINS (MG)    1.152         .000
  BSNOX  G/KW HR (G/HP HR)        5.818(  4.338) (  4.34) (CONT)     PARTICULATE GRAMS/TEST                .643
  PART.  G/KW HR (G/HP HR)         .074(   .055) (   .06)
  BSFC  KG/KW HR (LB/HP HR)        .317(   .521)
  WORK       KW HR (HP HR)         8.70(  11.67)
  BSCO2  G/KW HR (G/HP HR)        899. (   670.)
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                                        EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                               TEST  BC-C1          RUN                 DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                     DATE 11/10/95   TIME                     HCR 1.90  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                 COMPUTER PROGRAM  HDT 3.4-R              H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                        CELL  7      BAG CART 1                  ENGINE OIL
ENGINE SERIAL  6B7AA5.9                      NEAT REE                                 CATALYST

BAROMETER 736.1 MM HG (28.98 IN HG)    CVS:  74.0°F  RH 62. PCT  AH  80.6 GR/LB       ENGINE DEW PT. 14.8°C (58.6°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)       ENGINE: RH 48. PCT  AH 10.9 G/KG ( 76.2 GR/LB) NOX HUMIDITY C.F. 1.003
                                       REFERENCE WORK  8.69 KW HR (11.65 HP HR)       DRY-TO-WET C.F.   .975

                           SAMPLE             BACKGROUND
  FORMALDEHYDE
    PPM                      .448               .000
    MASS  MG               382.87
  ACETALDEHYDE
    PPM                      .180               .000
    MASS  MG               225.64
  ACROLEIN
    PPM                      .015               .000
    MASS  MG                23.48
  ACETONE
    PPM                      .000               .000
    MASS  MG                  .00
  PROPIONALDEHYDE
    PPM                      .002               .004
    MASS  MG                  .00
  CROTONALDEHYDE
    PPM                      .006               .000
    MASS  MG                11.25
  ISOBUTYR+MEK
    PPM                      .004               .000
    MASS  MG                 8.12
  BENZALDEHYDE
    PPM                      .002               .000
    MASS  MG                 4.75
  HEXANALDEHYDE
    PPM                      .009               .006
    MASS  MG                 9.47

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR           32.808         CROTONALD.    MG/HP-HR               .964
              ACETALDEHYDE MG/HP-HR           19.335         ISOBUTYR+MEK  MG/HP-HR               .696
              ACROLEIN     MG/HP-HR            2.012         BENZALDEHYDE  MG/HP-HR               .407
              ACETONE      MG/HP-HR             .000         HEXANALDEHYDE MG/HP-HR               .812
              PROPIONALD.  MG/HP-HR             .000
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                         SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                 EPA  HOT TRANS  ENGINE EMISSION RESULTS            PROJECT NO. 08-7507-001

ENGINE  NUMBER                                 TEST  BC-H1           RUN             DIESEL   REE       EM-2126-F
ENGINE MODEL  95 CUMMINS                       DATE 11/10/95    TIME                 HCR 1.90  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                   COMPUTER PROGRAM  HDT 3.4-R           H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                          CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                        NEAT REE                              CATALYST

BAROMETER 736.1 MM HG (28.98 IN HG)      CVS:  74.0°F  RH 58. PCT  AH  75.6 GR/LB        ENGINE DEW PT. 14.2°C (57.6°F)
ENGINE AIR TEMP. 27.8°C (82.0°F)         ENGINE: RH 43. PCT  AH 10.5 G/KG ( 73.4 GR/LB)  NOX HUMIDITY C.F.  .996
                                         REFERENCE WORK  8.69 KW HR (11.65 HP HR)        DRY-TO-WET C.F.   .977
BAG RESULTS
  BAG NUMBER                                 1
  TIME SECONDS                            1207.7
  TOT. BLOWER RATE SCMM (SCFM)          33.53 (1183.9)
  TOT. 90MM RATE SCMM (SCFM)              .06 ( 2.25)
  TOT. 20X20 RATE SCMM (SCFM)            1.55 ( 54.8)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)       .09 ( 3.07)
  TOTAL FLOW STD. CU. METRES(SCF)       709.1 ( 25039.)

  HC  SAMPLE METER/RANGE/PPM              .1/ 76/   5.77
  HC  BCKGRD METER/RANGE/PPM              .1/ 76/   4.34
  CO  SAMPLE METER/RANGE/PPM            10.0/ 12/   9.56
  CO  BCKGRD METER/RANGE/PPM             1.0/ 12/    .94
  CO2 SAMPLE METER/RANGE/PCT            73.7/ 11/  .6317
  CO2 BCKGRD METER/RANGE/PCT             8.4/ 11/  .0495
  NOX SAMPLE METER/RANGE/PPM (D)          .5/ 73/  38.70
  NOX BCKGRD METER/RANGE/PPM              .7/  2/    .70

  DILUTION FACTOR                            21.58
  HC  CONCENTRATION PPM                       1.63
  CO  CONCENTRATION PPM                       8.38
  CO2 CONCENTRATION PCT                      .5845
  NOX CONCENTRATION PPM                      37.13

  HC  MASS GRAMS                              .743
  CO  MASS GRAMS                             6.914
  CO2 MASS GRAMS                          7582.19
  NOX MASS GRAMS                            50.152
  FUEL  KG (LB)                         2.669 (  5.88)
  KW HR (HP HR)                          8.72 ( 11.69)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .085(   .064) (   .06) (CONT)     90 MM FLTR NUMBERS          2456.0-83   P90-
  BSCO   G/KW HR (G/HP HR)       .793(   .591) (   .59)            90 MM FLTR WT. GAINS (MG)       .961          .000
  BSNOX  G/KW HR (G/HP HR)      5.753(  4.290) (  4.29) (CONT)     PARTICULATE GRAMS/TEST                 .530
  PART.  G/KW HR (G/HP HR)       .061(   .045) (   .05)
  BSFC  KG/KW HR (LB/HP HR)      .306(   .503)
  WORK     KW HR (HP HR)         8.72(  11.69)
  BSCO2  G/KW HR (G/HP HR)      870. (   649.)
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                        SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                  TEST  BC-H1          RUN             DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                        DATE 11/10/95   TIME                 HCR 1.90  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                    COMPUTER PROGRAM  HDT 3.4-R          H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                           CELL  7      BAG CART 1              ENGINE OIL
ENGINE SERIAL  6B7AA5.9                         NEAT REE                             CATALYST

BAROMETER 736.1 MM HG (28.98 IN HG)     CVS:  74.0°F  RH 58. PCT  AH  75.6 GR/LB     ENGINE DEW PT. 14.2°C (57.6°F)
ENGINE AIR TEMP. 27.8°C (82.0°F)        ENGINE: RH 43. PCT  AH 10.5 G/KG ( 73.4 GR/LB) NOX HUMIDITY C.F.  .996
                                        REFERENCE WORK  8.69 KW HR (11.65 HP HR)     DRY-TO-WET C.F.   .977

                          SAMPLE              BACKGROUND
  FORMALDEHYDE
    PPM                    .315                 .000
    MASS  MG             272.77
  ACETALDEHYDE
    PPM                    .126                 .000
    MASS  MG             159.91
  ACROLEIN
    PPM                    .008                 .000
    MASS  MG              13.37
  ACETONE
    PPM                    .000                 .000
    MASS  MG                .00
  PROP
    PPM                    .001                 .004
    MASS  MG                .00
  CROTONALD.
    PPM                    .003                 .000
    MASS  MG               6.44
  ISOBUTYR+MEK
    PPM                    .001                 .000
    MASS  MG               1.94
  BENZALDEHYDE
    PPM                    .001                 .000
    MASS  MG               2.60
  HEXANALDEHYDE
    PPM                    .007                 .006
    MASS  MG               4.35

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR            23.334          CROTONALD.    MG/HP-HR              .551
              ACETALDEHYDE MG/HP-HR            13.679          ISOBUTYR+MEK  MG/HP-HR              .166
              ACROLEIN     MG/HP-HR             1.144          BENZALDEHYDE  MG/HP-HR              .222
              ACETONE      MG/HP-HR              .000          HEXANALDEHYDE MG/HP-HR              .372
              PROPIONALD.  MG/HP-HR              .000
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                                   EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                TEST  BC-H2           RUN            DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                      DATE 11/10/95   TIME                 HCR 1.90  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                  COMPUTER PROGRAM  HDT 3.4-R          H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                         CELL  7      BAG CART 1              ENGINE OIL
ENGINE SERIAL  6B7AA5.9                       NEAT REE                             CATALYST

BAROMETER 736.1 MM HG (28.98 IN HG)     CVS:  75.0°F  RH 59. PCT  AH  78.9 GR/LB      ENGINE DEW PT. 14.0°C (57.2°F)
ENGINE AIR TEMP. 27.8°C (82.0°F)        ENGINE: RH 43. PCT  AH 10.3 G/KG ( 72.3 GR/LB) NOX HUMIDITY C.F.   .993
                                        REFERENCE WORK  8.69 KW HR (11.65 HP HR)      DRY-TO-WET C.F.    .976
BAG RESULTS
  BAG NUMBER                                       1
  TIME SECONDS                                  1207.2
  TOT. BLOWER RATE SCMM (SCFM)               33.70 (1189.9)
  TOT. 90MM RATE SCMM (SCFM)                   .06 ( 2.29)
  TOT. 20X20 RATE SCMM (SCFM)                 1.54 ( 54.3)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)            .09 ( 3.02)
  TOTAL FLOW STD. CU. METRES(SCF)            712.0 ( 25141.)

  HC  SAMPLE METER/RANGE/PPM                  .1/ 76/   6.29
  HC  BCKGRD METER/RANGE/PPM                  .1/ 76/   4.83
  CO  SAMPLE METER/RANGE/PPM                 9.9/ 12/   9.46
  CO  BCKGRD METER/RANGE/PPM                  .7/ 12/    .66
  CO2 SAMPLE METER/RANGE/PCT                73.1/ 11/  .6245
  CO2 BCKGRD METER/RANGE/PCT                 8.4/ 11/  .0495
  NOX SAMPLE METER/RANGE/PPM (D)              .5/ 73/  37.97
  NOX BCKGRD METER/RANGE/PPM                  .6/  2/    .60

  DILUTION FACTOR                                  21.83
  HC  CONCENTRATION PPM                             1.68
  CO  CONCENTRATION PPM                             8.55
  CO2 CONCENTRATION PCT                            .5772
  NOX CONCENTRATION PPM                            36.49

  HC  MASS GRAMS                                    .769
  CO  MASS GRAMS                                   7.084
  CO2 MASS GRAMS                                 7518.92
  NOX MASS GRAMS                                  49.347
  FUEL  KG (LB)                              2.646 (  5.83)
  KW HR (HP HR)                               8.67 ( 11.63)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .089(   .066) (   .07) (CONT)      90 MM FLTR NUMBERS          2456.0-84   P90-
  BSCO   G/KW HR (G/HP HR)        .817(   .609) (   .61)             90 MM FLTR WT. GAINS (MG)      .982         .000
  BSNOX  G/KW HR (G/HP HR)       5.690(  4.243) (  4.24) (CONT)      PARTICULATE GRAMS/TEST                 .536
  PART.  G/KW HR (G/HP HR)        .062(   .046) (   .05)
  BSFC  KG/KW HR (LB/HP HR)       .305(   .502)
  WORK      KW HR (HP HR)         8.67(  11.63)
  BSCO2  G/KW HR (G/HP HR)       867. (   647.)
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                                        EPA  COLD TRANS ENGINE EMISSION RESULTS            PROJECT NO. 08-7507-001

ENGINE  NUMBER                                    TEST  B-C2           RUN                  DIESEL   REE       EM-2126-F
ENGINE MODEL  95 CUMMINS                          DATE 11/13/95   TIME                      HCR 1.90  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6                     COMPUTER PROGRAM  HDT 3.4-R               H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                             CELL  7      BAG CART 1                   ENGINE OIL
ENGINE SERIAL  6B7AA5.9                           NEAT REE

BAROMETER 739.6 MM HG (29.12 IN HG)        CVS:  78.0°F  RH 34. PCT  AH  49.6 GR/LB         ENGINE DEW PT. 13.7°C (56.7°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)           ENGINE: RH 45. PCT  AH 10.1 G/KG ( 70.7 GR/LB)   NOX HUMIDITY C.F.   .989
                                           REFERENCE WORK  8.69 KW HR (11.65 HP HR)         DRY-TO-WET C.F.   .983
BAG RESULTS
  BAG NUMBER                                     1
  TIME SECONDS                                 1207.2
  TOT. BLOWER RATE SCMM (SCFM)              33.59 (1186.0)
  TOT. 90MM RATE SCMM (SCFM)                  .06 ( 2.21)
  TOT. 20X20 RATE SCMM (SCFM)               1.59 ( 56.1)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)          .09 ( 3.04)
  TOTAL FLOW STD. CU. METRES(SCF)          710.7 ( 25096.)

  HC  SAMPLE METER/RANGE/PPM                 .1/ 76/   8.60
  HC  BCKGRD METER/RANGE/PPM                 .0/ 76/   4.11
  CO  SAMPLE METER/RANGE/PPM               21.2/ 12/  20.48
  CO  BCKGRD METER/RANGE/PPM                 .6/ 12/    .57
  CO2 SAMPLE METER/RANGE/PCT               73.5/ 11/  .6293
  CO2 BCKGRD METER/RANGE/PCT                8.2/ 11/  .0483
  NOX SAMPLE METER/RANGE/PPM (D)             .5/ 73/  38.92
  NOX BCKGRD METER/RANGE/PPM                 .5/  2/    .51

  DILUTION FACTOR                                21.62
  HC  CONCENTRATION PPM                           4.68
  CO  CONCENTRATION PPM                          19.47
  CO2 CONCENTRATION PCT                          .5832
  NOX CONCENTRATION PPM                          37.76

  HC  MASS GRAMS                                  2.137
  CO  MASS GRAMS                                 16.113
  CO2 MASS GRAMS                               7583.64
  NOX MASS GRAMS                                 50.749
  FUEL  KG (LB)                             2.676 (  5.90)
  KW HR (HP HR)                              8.53 ( 11.44)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)         .251(   .187) (   .19) (CONT)       90 MM FLTR NUMBERS          2458.0-104  P90-
  BSCO   G/KW HR (G/HP HR)        1.889(  1.409) (  1.41)              90 MM FLTR WT. GAINS (MG)      2.293          .000
  BSNOX  G/KW HR (G/HP HR)        5.949(  4.436) (  4.44) (CONT)       PARTICULATE GRAMS/TEST                1.292
  PART.  G/KW HR (G/HP HR)         .151(   .113) (   .11)
  BSFC  KG/KW HR (LB/HP HR)        .314(   .516)
  WORK      KW HR (HP HR)          8.53(  11.44)
  BSCO2  G/KW HR (G/HP HR)        889. (   663.)
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                                          EPA  COLD TRANS ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                  TEST  B-C2           RUN             DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                        DATE 11/13/95   TIME                 HCR 1.90  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                    COMPUTER PROGRAM  HDT 3.4-R          H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                           CELL  7      BAG CART 1              ENGINE OIL
ENGINE SERIAL  6B7AA5.9                         NEAT REE

BAROMETER 739.6 MM HG (29.12 IN HG)     CVS:  78.0°F  RH 34. PCT  AH  49.6 GR/LB     ENGINE DEW PT. 13.7°C (56.7°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)        ENGINE: RH 45. PCT  AH 10.1 G/KG ( 70.7 GR/LB) NOX HUMIDITY C.F.  .989
                                        REFERENCE WORK  8.69 KW HR (11.65 HP HR)     DRY-TO-WET C.F.   .983

                           SAMPLE               BACKGROUND
  FORMALDEHYDE
    PPM                      .482                 .004
    MASS  MG               417.00
  ACETALDEHYDE
    PPM                      .131                 .008
    MASS  MG               157.12
  ACROLEIN
    PPM                      .018                 .000
    MASS  MG                29.41
  ACETONE
    PPM                      .021                 .017
    MASS  MG                 7.48
  PROPIONALDEHYDE
    PPM                      .019                 .004
    MASS  MG                25.63
  CROTONALDEHYDE
    PPM                      .022                 .000
    MASS  MG                44.55
  ISOBUTYR+MEK
    PPM                      .017                 .006
    MASS  MG                23.27
  BENZALDEHYDE
    PPM                      .002                 .000
    MASS  MG                 6.61
  HEXANALDEHYDE
    PPM                      .007                 .000
    MASS  MG                20.04

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR             36.451           CROTONALD.    MG/HP-HR               3.894
              ACETALDEHYDE MG/HP-HR             13.735           ISOBUTYR+MEK  MG/HP-HR               2.034
              ACROLEIN     MG/HP-HR              2.571           BENZALDEHYDE  MG/HP-HR                .578
              ACETONE      MG/HP-HR               .653           HEXANALDEHYDE MG/HP-HR               1.752
              PROPIONALD.  MG/HP-HR              2.241
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                                  EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                          TEST  B-H3           RUN              DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                DATE 11/13/95   TIME                  HCR 1.90  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6           COMPUTER PROGRAM  HDT 3.4-R           H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                   CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                 NEAT REE

BAROMETER 739.4 MM HG (29.11 IN HG)    CVS:  77.0°F  RH 36. PCT  AH  51.3 GR/LB        ENGINE DEW PT. 13.7°C (56.6°F)
ENGINE AIR TEMP. 27.8°C (82.0°F)       ENGINE: RH 42. PCT  AH 10.1 G/KG ( 70.5 GR/LB)  NOX HUMIDITY C.F.  .988
                                       REFERENCE WORK  8.69 KW HR (11.65 HP HR)        DRY-TO-WET C.F.   .982
BAG RESULTS
  BAG NUMBER                                  1
  TIME SECONDS                             1207.8
  TOT. BLOWER RATE SCMM (SCFM)         33.76 (1191.9)
  TOT. 90MM RATE SCMM (SCFM)             .06 ( 2.20)
  TOT. 20X20 RATE SCMM (SCFM)           1.60 ( 56.3)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)      .09 ( 3.00)
  TOTAL FLOW STD. CU. METRES(SCF)      714.6 ( 25232.)

  HC  SAMPLE METER/RANGE/PPM             .1/ 76/   6.80
  HC  BCKGRD METER/RANGE/PPM             .1/ 76/   4.48
  CO  SAMPLE METER/RANGE/PPM           15.2/ 12/  14.61
  CO  BCKGRD METER/RANGE/PPM             .3/ 12/    .28
  CO2 SAMPLE METER/RANGE/PCT           72.1/ 11/  .6126
  CO2 BCKGRD METER/RANGE/PCT            7.9/ 11/  .0464
  NOX SAMPLE METER/RANGE/PPM (D)         .5/ 73/  38.31
  NOX BCKGRD METER/RANGE/PPM             .6/  2/    .62

  DILUTION FACTOR                            22.23
  HC  CONCENTRATION PPM                       2.52
  CO  CONCENTRATION PPM                      13.99
  CO2 CONCENTRATION PCT                      .5682
  NOX CONCENTRATION PPM                      37.05

  HC  MASS GRAMS                              1.158
  CO  MASS GRAMS                             11.642
  CO2 MASS GRAMS                           7428.39
  NOX MASS GRAMS                             50.038
  FUEL  KG (LB)                         2.618 (  5.77)
  KW HR (HP HR)                          8.55 ( 11.46)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)      .135(   .101) (   .10) (CONT)     90 MM FLTR NUMBERS          2473.0-105  P90-
  BSCO   G/KW HR (G/HP HR)     1.362(  1.016) (  1.02)            90 MM FLTR WT. GAINS (MG)      1.751        .000
  BSNOX  G/KW HR (G/HP HR)     5.855(  4.366) (  4.37) (CONT)     PARTICULATE GRAMS/TEST                  .996
  PART.  G/KW HR (G/HP HR)      .117(   .087) (   .09)
  BSFC  KG/KW HR (LB/HP HR)     .306(   .504)
  WORK      KW HR (HP HR)       8.55(  11.46)
  BSCO2  G/KW HR (G/HP HR)      869. (   648.)
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                                          EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                 TEST  B-H3           RUN                DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                       DATE 11/13/95   TIME                    HCR 1.90  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                   COMPUTER PROGRAM  HDT 3.4-R             H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                          CELL  7      BAG CART 1                 ENGINE OIL
ENGINE SERIAL  6B7AA5.9                        NEAT REE

BAROMETER 739.4 MM HG (29.11 IN HG)    CVS:  77.0°F  RH 36. PCT  AH  51.3 GR/LB        ENGINE DEW PT. 13.7°C (56.6°F)
ENGINE AIR TEMP. 27.8°C (82.0°F)       ENGINE: RH 42. PCT  AH 10.1 G/KG ( 70.5 GR/LB)  NOX HUMIDITY C.F.  .988
                                       REFERENCE WORK  8.69 KW HR (11.65 HP HR)        DRY-TO-WET C.F.   .982

                         SAMPLE               BACKGROUND
 FORMALDEHYDE
   PPM                     .286                  .004
   MASS  MG              247.22
 ACETALDEHYDE
   PPM                     .078                  .008
   MASS  MG               90.29
 ACROLEIN
   PPM                     .008                  .000
   MASS  MG               12.33
 ACETONE
   PPM                     .015                  .017
   MASS  MG                 .00
 PROP
   PPM                     .012                  .004
   MASS  MG               13.70
 CROTONALD.
   PPM                     .012                  .000
   MASS  MG               24.62
 ISOBUTYR+MEK
   PPM                     .012                  .006
   MASS  MG               11.23
 BENZALDEHYDE
   PPM                     .001                  .000
   MASS  MG                4.07
 HEXANALDEHYDE
   PPM                     .004                  .000
   MASS  MG               11.15

TOTAL RESULTS
             FORMALDEHYDE MG/HP-HR            21.573          CROTONALD.    MG/HP-HR             2.148
             ACETALDEHYDE MG/HP-HR             7.879          ISOBUTYR+MEK  MG/HP-HR              .980
             ACROLEIN     MG/HP-HR             1.076          BENZALDEHYDE  MG/HP-HR              .355
             ACETONE      MG/HP-HR              .000          HEXANALDEHYDE MG/HP-HR              .973
             PROPIONALD.  MG/HP-HR             1.196
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                                 EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                              TEST  B-H4           RUN              DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                    DATE 11/13/95   TIME                  HCR 1.90  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                COMPUTER PROGRAM  HDT 3.4-R           H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                       CELL  7     BAG CART 1                ENGINE OIL
ENGINE SERIAL  6B7AA5.9                     NEAT REE

BAROMETER 739.1 MM HG (29.10 IN HG)    CVS:  76.0°F  RH 35. PCT  AH  48.5 GR/LB        ENGINE DEW PT. 13.6°C (56.4°F)
ENGINE AIR TEMP. 27.8°C (82.0°F)       ENGINE: RH 42. PCT  AH 10.0 G/KG ( 70.0 GR/LB)  NOX HUMIDITY C.F.  .987
                                       REFERENCE WORK  8.69 KW HR (11.65 HP HR)        DRY-TO-WET C.F.   .983
BAG RESULTS
  BAG NUMBER                                    1
  TIME SECONDS                               1207.1
  TOT. BLOWER RATE SCMM (SCFM)             33.85 (1195.2)
  TOT. 90MM RATE SCMM (SCFM)                 .06 ( 2.24)
  TOT. 20X20 RATE SCMM (SCFM)               1.58 ( 55.7)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)          .09 ( 3.05)
  TOTAL FLOW STD. CU. METRES(SCF)          715.7 ( 25272.)

  HC  SAMPLE METER/RANGE/PPM                .1/ 76/   6.87
  HC  BCKGRD METER/RANGE/PPM                .1/ 76/   4.56
  CO  SAMPLE METER/RANGE/PPM              15.0/ 12/  14.41
  CO  BCKGRD METER/RANGE/PPM                .4/ 12/    .38
  CO2 SAMPLE METER/RANGE/PCT              71.8/ 11/  .6090
  CO2 BCKGRD METER/RANGE/PCT               7.7/ 11/  .0452
  NOX SAMPLE METER/RANGE/PPM (D)            .5/ 73/  38.38
  NOX BCKGRD METER/RANGE/PPM                .1/  2/    .10

  DILUTION FACTOR                               22.36
  HC  CONCENTRATION PPM                          2.51
  CO  CONCENTRATION PPM                         13.72
  CO2 CONCENTRATION PCT                         .5659
  NOX CONCENTRATION PPM                         37.63

  HC  MASS GRAMS                                 1.156
  CO  MASS GRAMS                                11.432
  CO2 MASS GRAMS                              7409.08
  NOX MASS GRAMS                                50.846
  FUEL  KG (LB)                            2.611 (  5.76)
  KW HR (HP HR)                             8.53 ( 11.44)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .136(   .101) (   .10) (CONT)     90 MM FLTR NUMBERS         2474.0-106  P90-
  BSCO   G/KW HR (G/HP HR)       1.340(   .999) (  1.00)            90 MM FLTR WT. GAINS (MG)     1.834          .000
  BSNOX  G/KW HR (G/HP HR)       5.960(  4.445) (  4.44) (CONT)     PARTICULATE GRAMS/TEST             1.026
  PART.  G/KW HR (G/HP HR)        .120(   .090) (   .09)
  BSFC  KG/KW HR (LB/HP HR)       .306(   .503)
  WORK     KW HR (HP HR)          8.53(  11.44)
  BSCO2  G/KW HR (G/HP HR)       869. (   648.)
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                                  EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                 TEST  C-C1          RUN               DIESEL   REE       EM-2126-F
ENGINE MODEL  95 CUMMINS                       DATE 11/14/95   TIME                  HCR 1.90  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6                  COMPUTER PROGRAM  HDT 3.4-R           H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                          CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                        NEAT RME

BAROMETER 745.5 MM HG (29.35 IN HG)     CVS:  74.0°F  RH 27. PCT  AH  34.4 GR/LB        ENGINE DEW PT. 12.9°C (55.3°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)        ENGINE: RH 43. PCT  AH  9.5 G/KG ( 66.6 GR/LB)  NOX HUMIDITY C.F.  .979
                                        REFERENCE WORK  8.75 KW HR (11.74 HP HR)        DRY-TO-WET C.F.   .986
BAG RESULTS
  BAG NUMBER                                     1
  TIME SECONDS                                1207.0
  TOT. BLOWER RATE SCMM (SCFM)              33.74 (1191.5)
  TOT. 90MM RATE SCMM (SCFM)                  .06 ( 2.25)
  TOT. 20X20 RATE SCMM (SCFM)                1.55 ( 54.9)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)           .09 ( 3.09)
  TOTAL FLOW STD. CU. METRES(SCF)           713.1 ( 25180.)

  HC  SAMPLE METER/RANGE/PPM                  .1/ 76/   7.60
  HC  BCKGRD METER/RANGE/PPM                  .1/ 76/   4.68
  CO  SAMPLE METER/RANGE/PPM                18.2/ 12/  17.54
  CO  BCKGRD METER/RANGE/PPM                  .6/ 12/    .57
  CO2 SAMPLE METER/RANGE/PCT                74.5/ 11/  .6414
  CO2 BCKGRD METER/RANGE/PCT                 8.3/ 11/  .0489
  NOX SAMPLE METER/RANGE/PPM (D)              .5/ 73/  41.65
  NOX BCKGRD METER/RANGE/PPM                  .4/  2/    .41

  DILUTION FACTOR                                21.22
  HC  CONCENTRATION PPM                           3.14
  CO  CONCENTRATION PPM                          16.63
  CO2 CONCENTRATION PCT                          .5948
  NOX CONCENTRATION PPM                          40.68

  HC  MASS GRAMS                                 1.439
  CO  MASS GRAMS                                13.808
  CO2 MASS GRAMS                               7759.50
  NOX MASS GRAMS                                54.287
  FUEL  KG (LB)                             2.735 (  6.03)
  KW HR (HP HR)                              8.83 ( 11.84)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .163(   .122) (   .12) (CONT)      90 MM FLTR NUMBERS          2475.0-107  P90-
  BSCO   G/KW HR (G/HP HR)      1.564(  1.166) (  1.17)             90 MM FLTR WT. GAINS (MG)      2.040          .000
  BSNOX  G/KW HR (G/HP HR)      6.149(  4.585) (  4.59) (CONT)      PARTICULATE GRAMS/TEST             1.135
  PART.  G/KW HR (G/HP HR)       .129(   .096) (   .10)
  BSFC  KG/KW HR (LB/HP HR)      .310(   .509)
  WORK      KW HR (HP HR)        8.83(  11.84)
  BSCO2  G/KW HR (G/HP HR)      879. (   655.)
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                        SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                             TEST  C-C1           RUN            DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                   DATE 11/14/95   TIME                HCR 1.90  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6               COMPUTER PROGRAM  HDT 3.4-R         H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                      CELL  7      BAG CART 1             ENGINE OIL
ENGINE SERIAL  6B7AA5.9                    NEAT RME

BAROMETER 745.5 MM HG (29.35 IN HG)    CVS:  74.0°F  RH 27. PCT  AH  34.4 GR/LB        ENGINE DEW PT. 12.9°C (55.3°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)       ENGINE: RH 43. PCT  AH  9.5 G/KG ( 66.6 GR/LB)  NOX HUMIDITY C.F.  .979
                                       REFERENCE WORK  8.75 KW HR (11.74 HP HR)        DRY-TO-WET C.F.   .986

                      SAMPLE            BACKGROUND
  FORMALDEHYDE
    PPM                 .390               .003
    MASS  MG          340.04
  ACETALDEHYDE
    PPM                 .083               .002
    MASS  MG          103.69
  ACROLEIN
    PPM                 .013               .001
    MASS  MG           18.70
  ACETONE
    PPM                 .016               .003
    MASS  MG           22.96
  PROPIONALDEHYDE
    PPM                 .016               .000
    MASS  MG           27.21
  CROTONALDEHYDE
    PPM                 .012               .000
    MASS  MG           24.62
  ISOBUTYR+MEK
    PPM                 .010               .000
    MASS  MG           20.68
  BENZALDEHYDE
    PPM                 .002               .000
    MASS  MG            6.44
  HEXANALDEHYDE
    PPM                 .005               .001
    MASS  MG           11.06

TOTAL RESULTS
             FORMALDEHYDE MG/HP-HR           28.719        CROTONALD.    MG/HP-HR          2.079
             ACETALDEHYDE MG/HP-HR            8.758        ISOBUTYR+MEK  MG/HP-HR          1.747
             ACROLEIN     MG/HP-HR            1.580        BENZALDEHYDE  MG/HP-HR           .544
             ACETONE      MG/HP-HR            1.940        HEXANALDEHYDE MG/HP-HR           .934
             PROPIONALD.  MG/HP-HR            2.298
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                              SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                         EPA  HOT TRANS  ENGINE EMISSION RESULTS         PROJECT NO. 08-7507-001

ENGINE  NUMBER                                       TEST  C-H1             RUN             DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                             DATE 11/14/95   TIME                   HCR 1.90  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                         COMPUTER PROGRAM  HDT 3.4-R            H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                                CELL  7      BAG CART 1                ENGINE OIL
ENGINE SERIAL  6B7AA5.9                              NEAT RME

BAROMETER 745.5 MM HG (29.35 IN HG)     CVS:  74.0°F  RH 27. PCT  AH  34.4 GR/LB            ENGINE DEW PT. 13.3°C (56.0°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)        ENGINE: RH 42. PCT  AH  9.8 G/KG ( 68.3 GR/LB)     NOX HUMIDITY C.F.  .983
                                        REFERENCE WORK  8.75 KW HR (11.74 HP HR)            DRY-TO-WET C.F.   .986
BAG RESULTS
  BAG NUMBER                                   1
  TIME SECONDS                              1207.0
  TOT. BLOWER RATE SCMM (SCFM)          33.86 (1195.7)
  TOT. 90MM RATE SCMM (SCFM)              .07 ( 2.31)
  TOT. 20X20 RATE SCMM (SCFM)            1.53 ( 54.1)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)       .09 ( 3.08)
  TOTAL FLOW STD. CU. METRES(SCF)       715.1 ( 25249.)

  HC  SAMPLE METER/RANGE/PPM              .1/ 76/   7.45
  HC  BCKGRD METER/RANGE/PPM              .1/ 76/   5.71
  CO  SAMPLE METER/RANGE/PPM            13.2/ 12/  12.66
  CO  BCKGRD METER/RANGE/PPM              .5/ 12/    .47
  CO2 SAMPLE METER/RANGE/PCT            72.7/ 11/  .6197
  CO2 BCKGRD METER/RANGE/PCT             8.0/ 11/  .0470
  NOX SAMPLE METER/RANGE/PPM (D)          .5/ 73/  41.01
  NOX BCKGRD METER/RANGE/PPM              .7/  2/    .72

  DILUTION FACTOR                              21.98
  HC  CONCENTRATION PPM                         2.00
  CO  CONCENTRATION PPM                        11.95
  CO2 CONCENTRATION PCT                        .5748
  NOX CONCENTRATION PPM                        39.76

  HC  MASS GRAMS                                 .919
  CO  MASS GRAMS                                9.947
  CO2 MASS GRAMS                             7519.40
  NOX MASS GRAMS                               53.444
  FUEL  KG (LB)                         2.648 (  5.84)
  KW HR (HP HR)                          8.81 ( 11.81)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)         .104(   .078) (   .08) (CONT)      90 MM FLTR NUMBERS          2459.0-126  P90-
  BSCO   G/KW HR (G/HP HR)        1.129(   .842) (   .84)             90 MM FLTR WT. GAINS (MG)     1.676          .000
  BSNOX  G/KW HR (G/HP HR)        6.069(  4.525) (  4.53) (CONT)      PARTICULATE GRAMS/TEST                  .910
  PART.  G/KW HR (G/HP HR)         .103(   .077) (   .08)
  BSFC  KG/KW HR (LB/HP HR)        .301(   .494)
  WORK      KW HR (HP HR)          8.81(  11.81)
  BSCO2  G/KW HR (G/HP HR)         854. (   637.)
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                                 SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                               EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                 TEST  C-H1           RUN                  DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                       DATE 11/14/95   TIME                      HCR 1.90  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6                  COMPUTER PROGRAM  HDT 3.4-R               H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                          CELL  7      BAG CART 1                   ENGINE OIL
ENGINE SERIAL  6B7AA5.9                        NEAT RME

BAROMETER 745.5 MM HG (29.35 IN HG)     CVS:  74.0°F  RH 27. PCT  AH  34.4 GR/LB         ENGINE DEW PT. 13.3°C (56.0°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)        ENGINE: RH 42. PCT  AH  9.8 G/KG ( 68.3 GR/LB)   NOX HUMIDITY C.F.  .983
                                        REFERENCE WORK  8.75 KW HR (11.74 HP HR)         DRY-TO-WET C.F.   .986

                          SAMPLE              BACKGROUND
  FORMALDEHYDE
    PPM                     .252                .003
    MASS  MG              219.53
  ACETALDEHYDE
    PPM                     .055                .002
    MASS  MG               68.47
  ACROLEIN
    PPM                     .013                .001
    MASS  MG               19.22
  ACETONE
    PPM                     .026                .003
    MASS  MG               39.14
  PROP
    PPM                     .013                .000
    MASS  MG               22.45
  CROTONALD.
    PPM                     .007                .000
    MASS  MG               14.09
  ISOBUTYR+MEK
    PPM                     .005                .000
    MASS  MG               11.31
  BENZALDEHYDE
    PPM                     .001                .000
    MASS  MG                4.27
  HEXANALDEHYDE
    PPM                     .002                .001
    MASS  MG                3.83

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR           18.588         CROTONALD.    MG/HP-HR           1.193
              ACETALDEHYDE MG/HP-HR            5.797         ISOBUTYR+MEK  MG/HP-HR            .958
              ACROLEIN     MG/HP-HR            1.627         BENZALDEHYDE  MG/HP-HR            .362
              ACETONE      MG/HP-HR            3.314         HEXANALDEHYDE MG/HP-HR            .324
              PROPIONALD.  MG/HP-HR            1.901
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                         SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                              TEST  C-H2           RUN           DIESEL   REE      EM-2126-F
ENGINE MODEL  95 CUMMINS                    DATE 11/14/95   TIME               HCR 1.90  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6               COMPUTER PROGRAM  HDT 3.4-R        H .124  C .777  O .099  X .000
ENGINE CYCLE   DIESEL                       CELL  7     BAG CART 1             ENGINE OIL
ENGINE SERIAL  6B7AA5.9                     NEAT RME

BAROMETER 745.5 MM HG (29.35 IN HG)    CVS:  74.0°F  RH 27. PCT  AH  34.4 GR/LB        ENGINE DEW PT. 13.4°C (56.1°F)
ENGINE AIR TEMP. 27.8°C (82.0°F)       ENGINE: RH 41. PCT  AH  9.8 G/KG ( 68.6 GR/LB)  NOX HUMIDITY C.F.  .984
                                       REFERENCE WORK  8.75 KW HR (11.74 HP HR)        DRY-TO-WET C.F.   .986
BAG RESULTS
  BAG NUMBER                                    1
  TIME SECONDS                               1207.4
  TOT. BLOWER RATE SCMM (SCFM)             34.15 (1205.9)
  TOT. 90MM RATE SCMM (SCFM)                 .07 ( 2.32)
  TOT. 20X20 RATE SCMM (SCFM)               1.58 ( 55.7)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)          .09 ( 3.06)
  TOTAL FLOW STD. CU. METRES(SCF)          722.1 ( 25496.)

  HC  SAMPLE METER/RANGE/PPM                .1/ 76/   7.18
  HC  BCKGRD METER/RANGE/PPM                .1/ 76/   5.37
  CO  SAMPLE METER/RANGE/PPM              14.0/ 12/  13.44
  CO  BCKGRD METER/RANGE/PPM               1.0/ 12/    .94
  CO2 SAMPLE METER/RANGE/PCT              72.5/ 11/  .6173
  CO2 BCKGRD METER/RANGE/PCT               8.1/ 11/  .0476
  NOX SAMPLE METER/RANGE/PPM (D)            .5/ 73/  40.14
  NOX BCKGRD METER/RANGE/PPM                .7/  2/    .72

  DILUTION FACTOR                               22.06
  HC  CONCENTRATION PPM                          2.05
  CO  CONCENTRATION PPM                         12.26
  CO2 CONCENTRATION PCT                         .5718
  NOX CONCENTRATION PPM                         38.90

  HC  MASS GRAMS                                  .953
  CO  MASS GRAMS                                10.310
  CO2 MASS GRAMS                              7553.64
  NOX MASS GRAMS                                52.837
  FUEL  KG (LB)                            2.661 (  5.87)
  KW HR (HP HR)                             8.76 ( 11.75)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .109(   .081) (   .08) (CONT)     90 MM FLTR NUMBERS          2460.0,127  P90-
  BSCO   G/KW HR (G/HP HR)      1.177(   .877) (   .88)            90 MM FLTR WT. GAINS (MG)     1.684         .000
  BSNOX  G/KW HR (G/HP HR)      6.030(  4.497) (  4.50) (CONT)     PARTICULATE GRAMS/TEST                .920
  PART.  G/KW HR (G/HP HR)       .105(   .078) (   .08)
  BSFC  KG/KW HR (LB/HP HR)      .304(   .499)
  WORK     KW HR (HP HR)         8.76(  11.75)
  BSCO2  G/KW HR (G/HP HR)      862. (   643.)
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                       SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                               EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                             TEST  CC-C1          RUN              DIESEL   RME      EM-2130-F
ENGINE MODEL  95 CUMMINS                   DATE 11/15/95   TIME                  HCR 1.92  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6               COMPUTER PROGRAM  HDT 3.4-R           H .126  C .782  O .092  X .000
ENGINE CYCLE   DIESEL                      CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                    NEAT RME                              CATALYST

BAROMETER 744.5 MM HG (29.31 IN HG)     CVS:  73.0°F  RH 39. PCT  AH  48.6 GR/LB       ENGINE DEW PT. 13.2°C (55.7°F)
ENGINE AIR TEMP. 25.0°C (77.0°F)        ENGINE: RH 48. PCT  AH  9.7 G/KG ( 67.7 GR/LB) NOX HUMIDITY C.F.  .981
                                        REFERENCE WORK  8.80 KW HR (11.80 HP HR)       DRY-TO-WET C.F.   .983
BAG RESULTS
  BAG NUMBER                                   1
  TIME SECONDS                              1207.7
  TOT. BLOWER RATE SCMM (SCFM)            33.77 (1192.3)
  TOT. 90MM RATE SCMM (SCFM)                .06 ( 2.29)
  TOT. 20X20 RATE SCMM (SCFM)              1.53 ( 54.1)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)         .09 ( 3.11)
  TOTAL FLOW STD. CU. METRES(SCF)         713.6 ( 25196.)

  HC  SAMPLE METER/RANGE/PPM                .1/ 76/   6.82
  HC  BCKGRD METER/RANGE/PPM                .1/ 76/   4.45
  CO  SAMPLE METER/RANGE/PPM              14.8/ 12/  14.22
  CO  BCKGRD METER/RANGE/PPM               1.3/ 12/   1.23
  CO2 SAMPLE METER/RANGE/PCT              74.0/ 11/  .6353
  CO2 BCKGRD METER/RANGE/PCT               8.1/ 11/  .0476
  NOX SAMPLE METER/RANGE/PPM (D)            .5/ 73/  41.40
  NOX BCKGRD METER/RANGE/PPM                .7/  2/    .72

  DILUTION FACTOR                               21.32
  HC  CONCENTRATION PPM                          2.58
  CO  CONCENTRATION PPM                         12.70
  CO2 CONCENTRATION PCT                         .5899
  NOX CONCENTRATION PPM                         40.00

  HC  MASS GRAMS                                 1.175
  CO  MASS GRAMS                                10.553
  CO2 MASS GRAMS                              7700.52
  NOX MASS GRAMS                                53.568
  FUEL  KG (LB)                           2.695 (  5.94)
  KW HR (HP HR)                            8.86 ( 11.88)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .133(   .099) (   .10) (CONT)     90 MM FLTR NUMBERS          2461.0-128  P90-
  BSCO   G/KW HR (G/HP HR)      1.191(   .888) (   .89)            90 MM FLTR WT. GAINS (MG)     1.127          .000
  BSNOX  G/KW HR (G/HP HR)      6.047(  4.509) (  4.51) (CONT)     PARTICULATE GRAMS/TEST              .615
  PART.  G/KW HR (G/HP HR)       .069(   .052) (   .05)
  BSFC  KG/KW HR (LB/HP HR)      .304(   .500)
  WORK      KW HR (HP HR)        8.86(  11.88)
  BSCO2  G/KW HR (G/HP HR)      869. (   648.)
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                                        EPA  COLD TRANS ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                               TEST  CC-C1          RUN                DIESEL   RME      EM-2130-F
ENGINE MODEL  95 CUMMINS                     DATE 11/15/95   TIME                    HCR 1.92  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                 COMPUTER PROGRAM  HDT 3.4-R             H .126  C .782  O .092  X .000
ENGINE CYCLE   DIESEL                        CELL  7      BAG CART 1                 ENGINE OIL
ENGINE SERIAL  6B7AA5.9                      NEAT RME                                CATALYST

BAROMETER 744.5 MM HG (29.31 IN HG)    CVS:  73.0°F  RH 39. PCT  AH  48.6 GR/LB           ENGINE DEW PT. 13.2°C (55.7°F)
ENGINE AIR TEMP. 25.0°C (77.0°F)       ENGINE: RH 48. PCT  AH  9.7 G/KG ( 67.7 GR/LB)  NOX HUMIDITY C.F.  .981
                                       REFERENCE WORK  8.80 KW HR (11.80 HP HR)          DRY-TO-WET C.F.   .983

                          SAMPLE               BACKGROUND
  FORMALDEHYDE
    PPM                    .457                  .004
    MASS  MG             397.00
  ACETALDEHYDE
    PPM                    .139                  .003
    MASS  MG             174.36
  ACROLEIN
    PPM                    .012                  .000
    MASS  MG              18.99
  ACETONE
    PPM                    .018                  .009
    MASS  MG              16.18
  PROPIONALDEHYDE
    PPM                    .016                  .006
    MASS  MG              17.45
  CROTONALDEHYDE
    PPM                    .006                  .000
    MASS  MG              13.08
  ISOBUTYR+MEK
    PPM                    .007                  .000
    MASS  MG              14.27
  BENZALDEHYDE
    PPM                    .000                  .000
    MASS  MG                .13
  HEXANALDEHYDE
    PPM                    .006                  .000
    MASS  MG              16.53

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR           33.418        CROTONALD.    MG/HP-HR            1.101
              ACETALDEHYDE MG/HP-HR           14.677        ISOBUTYR+MEK  MG/HP-HR            1.201
              ACROLEIN     MG/HP-HR            1.599        BENZALDEHYDE  MG/HP-HR             .011
              ACETONE      MG/HP-HR            1.362        HEXANALDEHYDE MG/HP-HR            1.391
              PROPIONALD.  MG/HP-HR            1.469
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                                  EPA  HOT TRANS  ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                  TEST  CC-H1           RUN           DIESEL   RME      EM-2130-F
ENGINE MODEL  95 CUMMINS                        DATE 11/15/95   TIME                HCR 1.92  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                    COMPUTER PROGRAM  HDT 3.4-R         H .126  C .782  O .092  X .000
ENGINE CYCLE   DIESEL                           CELL  7      BAG CART 1             ENGINE OIL
ENGINE SERIAL  6B7AA5.9                         NEAT RME                            CATALYST

BAROMETER 744.7 MM HG (29.32 IN HG)     CVS:  74.0°F  RH 40. PCT  AH  51.3 GR/LB        ENGINE DEW PT. 13.3°C (55.9°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)        ENGINE: RH 45. PCT  AH  9.7 G/KG ( 68.2 GR/LB)  NOX HUMIDITY C.F.  .983
                                        REFERENCE WORK  8.80 KW HR (11.80 HP HR)        DRY-TO-WET C.F.   .982
BAG RESULTS
  BAG NUMBER                                   1
  TIME SECONDS                              1207.1
  TOT. BLOWER RATE SCMM (SCFM)            33.89 (1196.6)
  TOT. 90MM RATE SCMM (SCFM)                .06 ( 2.28)
  TOT. 20X20 RATE SCMM (SCFM)              1.57 ( 55.5)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)         .09 ( 3.10)
  TOTAL FLOW STD. CU. METRES(SCF)         716.5 ( 25298.)

  HC  SAMPLE METER/RANGE/PPM                .1/ 76/   5.80
  HC  BCKGRD METER/RANGE/PPM                .1/ 76/   4.60
  CO  SAMPLE METER/RANGE/PPM               9.7/ 12/   9.27
  CO  BCKGRD METER/RANGE/PPM               1.0/ 12/    .94
  CO2 SAMPLE METER/RANGE/PCT              72.6/ 11/  .6185
  CO2 BCKGRD METER/RANGE/PCT               8.3/ 11/  .0489
  NOX SAMPLE METER/RANGE/PPM (D)            .5/ 73/  40.52
  NOX BCKGRD METER/RANGE/PPM                .5/  2/    .51

  DILUTION FACTOR                                21.92
  HC  CONCENTRATION PPM                           1.41
  CO  CONCENTRATION PPM                           8.14
  CO2 CONCENTRATION PCT                          .5719
  NOX CONCENTRATION PPM                          39.31

  HC  MASS GRAMS                                  .645
  CO  MASS GRAMS                                 6.793
  CO2 MASS GRAMS                               7495.23
  NOX MASS GRAMS                                52.925
  FUEL  KG (LB)                           2.621 (  5.78)
  KW HR (HP HR)                            8.84 ( 11.85)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .073(  .054) (  .05) (CONT)     90 MM FLTR NUMBERS          2543.0-135  P90-
  BSCO   G/KW HR (G/HP HR)       .769(  .573) (  .57)            90 MM FLTR WT. GAINS (MG)       .879          .000
  BSNOX  G/KW HR (G/HP HR)      5.989( 4.466) ( 4.47) (CONT)     PARTICULATE GRAMS/TEST               .484
  PART.  G/KW HR (G/HP HR)       .055(  .041) (  .04)
  BSFC  KG/KW HR (LB/HP HR)      .297(  .488)
  WORK     KW HR (HP HR)         8.84( 11.85)
  BSCO2  G/KW HR (G/HP HR)      848. (  633.)
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                          SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                   EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                               TEST  CC-H1           RUN              DIESEL   RME      EM-2130-F
ENGINE MODEL  95 CUMMINS                     DATE 11/15/95   TIME                   HCR 1.92  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                 COMPUTER PROGRAM  HDT 3.4-R            H .126  C .782  O .092  X .000
ENGINE CYCLE   DIESEL                        CELL  7      BAG CART 1                ENGINE OIL
ENGINE SERIAL  6B7AA5.9                      NEAT RME                               CATALYST

BAROMETER 744.7 MM HG (29.32 IN HG)    CVS:  74.0°F  RH 40. PCT  AH  51.3 GR/LB     ENGINE DEW PT. 13.3°C (55.9°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)       ENGINE: RH 45. PCT  AH  9.7 G/KG ( 68.2 GR/LB) NOX HUMIDITY C.F.  .983
                                       REFERENCE WORK  8.80 KW HR (11.80 HP HR)     DRY-TO-WET C.F.   .982

                        SAMPLE               BACKGROUND
 FORMALDEHYDE
   PPM                    .316                  .004
   MASS  MG             274.39
 ACETALDEHYDE
   PPM                    .098                  .003
   MASS  MG             122.54
 ACROLEIN
   PPM                    .006                  .000
   MASS  MG               9.66
 ACETONE
   PPM                    .022                  .009
   MASS  MG              22.03
 PROP
   PPM                    .010                  .006
   MASS  MG               8.21
 CROTONALD.
   PPM                    .003                  .000
   MASS  MG               6.52
 ISOBUTYR+MEK
   PPM                    .005                  .000
   MASS  MG              10.74
 BENZALDEHYDE
   PPM                    .000                  .000
   MASS  MG                .00
 HEXANALDEHYDE
   PPM                    .003                  .000
   MASS  MG               9.47

TOTAL RESULTS
            FORMALDEHYDE MG/HP-HR           23.156          CROTONALD.    MG/HP-HR            .550
            ACETALDEHYDE MG/HP-HR           10.341          ISOBUTYR+MEK  MG/HP-HR            .906
            ACROLEIN     MG/HP-HR             .815          BENZALDEHYDE  MG/HP-HR            .000
            ACETONE      MG/HP-HR            1.859          HEXANALDEHYDE MG/HP-HR            .799
            PROPIONALD.  MG/HP-HR             .693
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                                           EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                       TEST  CC-H2          RUN             DIESEL   RME      EM-2130-F
ENGINE MODEL  95 CUMMINS                             DATE 11/15/95   TIME 10:55           HCR 1.92  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                         COMPUTER PROGRAM  HDT 3.4-R          H .126  C .782  O .092  X .000
ENGINE CYCLE   DIESEL                                CELL  7       BAG CART 1             ENGINE OIL
ENGINE SERIAL  6B7AA5.9                              NEAT RME                             CATALYST

BAROMETER 744.7 MM HG (29.32 IN HG)      CVS:  74.0°F  RH 40. PCT  AH  51.3 GR/LB         ENGINE DEW PT. 13.3°C (56.0°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)         ENGINE: RH 44. PCT  AH  9.8 G/KG ( 68.4 GR/LB)   NOX HUMIDITY C.F.  .983
                                         REFERENCE WORK  8.80 KW HR (11.80 HP HR)         DRY-TO-WET C.F.   .982
BAG RESULTS
  BAG NUMBER                                     1
  TIME SECONDS                                1207.9
  TOT. BLOWER RATE SCMM (SCFM)             33.81 (1194.0)
  TOT. 90MM RATE SCMM (SCFM)                 .06 ( 2.29)
  TOT. 20X20 RATE SCMM (SCFM)               1.59 ( 56.1)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)          .09 ( 3.07)
  TOTAL FLOW STD. CU. METRES(SCF)          715.8 ( 25273.)

  HC  SAMPLE METER/RANGE/PPM                .1/ 76/   5.76
  HC  BCKGRD METER/RANGE/PPM                .1/ 76/   4.37
  CO  SAMPLE METER/RANGE/PPM               9.8/ 12/   9.36
  CO  BCKGRD METER/RANGE/PPM               1.3/ 12/   1.23
  CO2 SAMPLE METER/RANGE/PCT              73.2/ 11/  .6257
  CO2 BCKGRD METER/RANGE/PCT               8.0/ 11/  .0470
  NOX SAMPLE METER/RANGE/PPM (D)            .5/ 73/  40.12
  NOX BCKGRD METER/RANGE/PPM                .1/  2/    .10

  DILUTION FACTOR                                21.67
  HC  CONCENTRATION PPM                           1.59
  CO  CONCENTRATION PPM                           7.97
  CO2 CONCENTRATION PCT                          .5808
  NOX CONCENTRATION PPM                          39.31

  HC  MASS GRAMS                                  .727
  CO  MASS GRAMS                                 6.641
  CO2 MASS GRAMS                              7605.39
  NOX MASS GRAMS                                52.904
  FUEL  KG (LB)                            2.659 (  5.86)
  KW HR (HP HR)                             8.80 ( 11.80)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .083(   .062) (   .06) (CONT)      90 MM FLTR NUMBERS            2544.0-136  P90-
  BSCO   G/KW HR (G/HP HR)       .755(   .563) (   .56)             90 MM FLTR WT. GAINS (MG)        .860         .000
  BSNOX  G/KW HR (G/HP HR)      6.012(  4.483) (  4.48) (CONT)      PARTICULATE GRAMS/TEST                 .472
  PART.  G/KW HR (G/HP HR)       .054(   .040) (   .04)
  BSFC  KG/KW HR (LB/HP HR)      .302(   .497)
  WORK      KW HR (HP HR)        8.80(  11.80)
  BSCO2  G/KW HR (G/HP HR)      864. (   645.)
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                        SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                  EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                              TEST  DC-C1           RUN              DIESEL   REE50    EM-2134-F
ENGINE MODEL  95 CUMMINS                    DATE 11/16/95   TIME 10:45             HCR 1.83  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                COMPUTER PROGRAM  HDT 3.4-R            H .126  C .819  O .055  X .000
ENGINE CYCLE   DIESEL                       CELL  7      BAG CART 1                ENGINE OIL
ENGINE SERIAL  6B7AA5.9                     REE50                                  CATALYST

BAROMETER 746.3 MM HG (29.38 IN HG)   CVS:  73.0°F  RH 33. PCT  AH  40.0 GR/LB      ENGINE DEW PT. 12.9°C (55.3°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)      ENGINE: RH 44. PCT  AH  9.5 G/KG ( 66.5 GR/LB) NOX HUMIDITY C.F.  .978
                                      REFERENCE WORK  8.91 KW HR (11.95 HP HR)      DRY-TO-WET C.F.   .985
BAG RESULTS
  BAG NUMBER                                  1
  TIME SECONDS                             1207.4
  TOT. BLOWER RATE SCMM (SCFM)          33.90 (1197.0)
  TOT. 90MM RATE SCMM (SCFM)              .07 ( 2.30)
  TOT. 20X20 RATE SCMM (SCFM)            1.53 ( 53.9)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)       .09 ( 3.11)
  TOTAL FLOW STD. CU. METRES(SCF)       715.9 ( 25280.)

  HC  SAMPLE METER/RANGE/PPM              .1/ 76/   8.06
  HC  BCKGRD METER/RANGE/PPM              .0/ 76/   3.89
  CO  SAMPLE METER/RANGE/PPM            16.4/ 12/  15.78
  CO  BCKGRD METER/RANGE/PPM              .7/ 12/    .66
  CO2 SAMPLE METER/RANGE/PCT            74.0/ 11/  .6353
  CO2 BCKGRD METER/RANGE/PCT             8.1/ 11/  .0476
  NOX SAMPLE METER/RANGE/PPM (D)          .5/ 73/  41.40
  NOX BCKGRD METER/RANGE/PPM              .6/  2/    .62

  DILUTION FACTOR                             21.47
  HC  CONCENTRATION PPM                        4.35
  CO  CONCENTRATION PPM                       14.80
  CO2 CONCENTRATION PCT                       .5899
  NOX CONCENTRATION PPM                       40.19

  HC  MASS GRAMS                              1.899
  CO  MASS GRAMS                             12.333
  CO2 MASS GRAMS                            7726.00
  NOX MASS GRAMS                             53.843
  FUEL  KG (LB)                         2.584 (  5.70)
  KW HR (HP HR)                          8.98 ( 12.04)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .211(   .158) (   .16) (CONT)     90 MM FLTR NUMBERS          2445.0-137  P90-
  BSCO   G/KW HR (G/HP HR)      1.374(  1.024) (  1.02)            90 MM FLTR WT. GAINS (MG)     1.411         .000
  BSNOX  G/KW HR (G/HP HR)      5.997(  4.472) (  4.47) (CONT)     PARTICULATE GRAMS/TEST              .769
  PART.  G/KW HR (G/HP HR)       .086(   .064) (   .06)
  BSFC  KG/KW HR (LB/HP HR)      .288(   .473)
  WORK      KW HR (HP HR)        8.98(  12.04)
  BSCO2  G/KW HR (G/HP HR)      861. (   642.)
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                                  EPA  COLD TRANS ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                   TEST  DC-C1          RUN              DIESEL   REE50    EM-2134-F
ENGINE MODEL  95 CUMMINS                         DATE 11/16/95   TIME 10:45            HCR 1.83  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                     COMPUTER PROGRAM  HDT 3.4-R           H .126  C .819  O .055  X .000
ENGINE CYCLE   DIESEL                            CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                          REE50                                 CATALYST

BAROMETER 746.3 MM HG (29.38 IN HG)      CVS:  73.0°F  RH 33. PCT  AH  40.0 GR/LB      ENGINE DEW PT. 12.9°C (55.3°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)         ENGINE: RH 44. PCT  AH  9.5 G/KG ( 66.5 GR/LB) NOX HUMIDITY C.F.  .978
                                         REFERENCE WORK  8.91 KW HR (11.95 HP HR)       DRY-TO-WET C.F.   .985

                          SAMPLE              BACKGROUND
  FORMALDEHYDE
    PPM                     .485                .004
    MASS  MG              423.30
  ACETALDEHYDE
    PPM                     .181                .003
    MASS  MG              229.82
  ACROLEIN
    PPM                     .016                .000
    MASS  MG               26.70
  ACETONE
    PPM                     .029                .009
    MASS  MG               34.38
  PROPIONALDEHYDE
    PPM                     .019                .001
    MASS  MG               29.49
  CROTONALDEHYDE
    PPM                     .013                .000
    MASS  MG               26.59
  ISOBUTYR+MEK
    PPM                     .007                .000
    MASS  MG               14.24
  BENZALDEHYDE
    PPM                     .003                .000
    MASS  MG                8.12
  HEXANALDEHYDE
    PPM                     .001                .000
    MASS  MG                4.04

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR            35.158          CROTONALD.     MG/HP-HR             2.208
              ACETALDEHYDE MG/HP-HR            19.088          ISOBUTYR+MEK   MG/HP-HR             1.183
              ACROLEIN     MG/HP-HR             2.218          BENZALDEHYDE   MG/HP-HR              .674
              ACETONE      MG/HP-HR             2.855          HEXANALDEHYDE  MG/HP-HR              .335
              PROPIONALD.  MG/HP-HR             2.449
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                        SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                  TEST  DC-H1           RUN            DIESEL   REE50    EM-2134-F
ENGINE MODEL  95 CUMMINS                        DATE 11/16/95   TIME 11:25           HCR 1.83  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                    COMPUTER PROGRAM  HDT 3.4-R          H .126  C .819  O .055  X .000
ENGINE CYCLE   DIESEL                           CELL  7      BAG CART 1              ENGINE OIL
ENGINE SERIAL  6B7AA5.9                         REE50                                CATALYST

BAROMETER 745.7 MM HG (29.36 IN HG)     CVS:  74.0°F  RH 33. PCT  AH  42.6 GR/LB         ENGINE DEW PT. 13.2°C (55.8°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)        ENGINE: RH 43. PCT  AH  9.7 G/KG ( 67.8 GR/LB)  NOX HUMIDITY C.F.  .982
                                        REFERENCE WORK  8.91 KW HR (11.95 HP HR)         DRY-TO-WET C.F.   .984
BAG RESULTS
  BAG NUMBER                                      1
  TIME SECONDS                                 1207.2
  TOT. BLOWER RATE SCMM (SCFM)              33.87 (1196.1)
  TOT. 90MM RATE SCMM (SCFM)                  .07 ( 2.32)
  TOT. 20X20 RATE SCMM (SCFM)                1.57 ( 55.4)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)           .09 ( 3.09)
  TOTAL FLOW STD. CU. METRES(SCF)           716.2 ( 25289.)

  HC  SAMPLE METER/RANGE/PPM                 .1/ 76/   6.18
  HC  BCKGRD METER/RANGE/PPM                 .0/ 76/   3.21
  CO  SAMPLE METER/RANGE/PPM               11.0/ 12/  10.52
  CO  BCKGRD METER/RANGE/PPM                 .8/ 12/    .76
  CO2 SAMPLE METER/RANGE/PCT               73.7/ 11/  .6317
  CO2 BCKGRD METER/RANGE/PCT                7.8/ 11/  .0458
  NOX SAMPLE METER/RANGE/PPM (D)             .5/ 73/  40.31
  NOX BCKGRD METER/RANGE/PPM                 .4/  2/    .41

  DILUTION FACTOR                                21.61
  HC  CONCENTRATION PPM                           3.12
  CO  CONCENTRATION PPM                           9.57
  CO2 CONCENTRATION PCT                          .5880
  NOX CONCENTRATION PPM                          39.29

  HC  MASS GRAMS                                 1.361
  CO  MASS GRAMS                                 7.979
  CO2 MASS GRAMS                               7704.31
  NOX MASS GRAMS                                52.830
  FUEL  KG (LB)                             2.574 (  5.67)
  KW HR (HP HR)                              9.00 ( 12.07)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .151(    .113) (    .11) (CONT)      90 MM FLTR NUMBERS          2552.0-141  P90-
  BSCO   G/KW HR (G/HP HR)       .887(    .661) (    .66)             90 MM FLTR WT. GAINS (MG)     1.269        .000
  BSNOX  G/KW HR (G/HP HR)      5.870(   4.377) (   4.38) (CONT)      PARTICULATE GRAMS/TEST                .687
  PART.  G/KW HR (G/HP HR)       .076(    .057) (    .06)
  BSFC  KG/KW HR (LB/HP HR)      .286(    .470)
  WORK      KW HR (HP HR)        9.00(   12.07)
  BSCO2  G/KW HR (G/HP HR)      856. (    638.)
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                                         EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                  TEST  DC-H1          RUN                DIESEL   REE50    EM-2134-F
ENGINE MODEL  95 CUMMINS                        DATE 11/16/95   TIME 11:25              HCR 1.83  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6                   COMPUTER PROGRAM  HDT 3.4-R             H .126  C .819  O .055  X .000
ENGINE CYCLE   DIESEL                           CELL  7      BAG CART 1                 ENGINE OIL
ENGINE SERIAL  6B7AA5.9                         REE50                                   CATALYST

BAROMETER 745.7 MM HG (29.36 IN HG)      CVS:  74.0°F  RH 33. PCT  AH  42.6 GR/LB       ENGINE DEW PT. 13.2°C (55.8°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)         ENGINE: RH 43. PCT  AH  9.7 G/KG ( 67.8 GR/LB) NOX HUMIDITY C.F.  .982
                                         REFERENCE WORK  8.91 KW HR (11.95 HP HR)       DRY-TO-WET C.F.   .984

                        SAMPLE              BACKGROUND
 FORMALDEHYDE
   PPM                    .318                 .004
   MASS  MG             276.52
 ACETALDEHYDE
   PPM                    .123                 .003
   MASS  MG             155.69
 ACROLEIN
   PPM                    .007                 .000
   MASS  MG              12.26
 ACETONE
   PPM                    .020                 .009
   MASS  MG              19.63
 PROP
   PPM                    .010                 .001
   MASS  MG              14.71
 CROTONALD.
   PPM                    .008                 .000
   MASS  MG              15.65
 ISOBUTYR+MEK
   PPM                    .005                 .000
   MASS  MG               9.71
 BENZALDEHYDE
   PPM                    .001                 .000
   MASS  MG               4.05
 HEXANALDEHYDE
   PPM                    .000                 .000
   MASS  MG                .00

TOTAL RESULTS
             FORMALDEHYDE MG/HP-HR          22.910        CROTONALD.    MG/HP-HR          1.296
             ACETALDEHYDE MG/HP-HR          12.899        ISOBUTYR+MEK  MG/HP-HR           .804
             ACROLEIN     MG/HP-HR           1.016        BENZALDEHYDE  MG/HP-HR           .336
             ACETONE      MG/HP-HR           1.627        HEXANALDEHYDE MG/HP-HR           .000
             PROPIONALD.  MG/HP-HR           1.219
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                                  EPA  HOT TRANS  ENGINE EMISSION RESULTS            PROJECT NO. 08-7507-001

ENGINE  NUMBER                                      TEST  DC-H2           RUN             DIESEL   REE50    EM-2134-F
ENGINE MODEL  95 CUMMINS                            DATE 11/16/95   TIME 12:05            HCR 1.83  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                        COMPUTER PROGRAM  HDT 3.4-R           H .126  C .819  O .055  X .000
ENGINE CYCLE   DIESEL                               CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                             REE50                                 CATALYST

BAROMETER 745.2 MM HG (29.34 IN HG)      CVS:  71.0°F  RH 38. PCT  AH  43.4 GR/LB         ENGINE DEW PT. 13.3°C (55.9°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)         ENGINE: RH 44. PCT  AH  9.7 G/KG ( 68.1 GR/LB)   NOX HUMIDITY C.F.   .982
                                         REFERENCE WORK  8.91 KW HR (11.95 HP HR)         DRY-TO-WET C.F.   .984
BAG RESULTS
  BAG NUMBER                                        1
  TIME SECONDS                                 1207.6
  TOT. BLOWER RATE SCMM (SCFM)               33.97 (1199.5)
  TOT. 90MM RATE SCMM (SCFM)                   .06 ( 2.29)
  TOT. 20X20 RATE SCMM (SCFM)                 1.53 ( 54.0)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)            .09 ( 3.09)
  TOTAL FLOW STD. CU. METRES(SCF)            717.6 ( 25338.)

  HC  SAMPLE METER/RANGE/PPM                  .1/ 76/   6.56
  HC  BCKGRD METER/RANGE/PPM                  .0/ 76/   3.49
  CO  SAMPLE METER/RANGE/PPM                11.7/ 12/  11.20
  CO  BCKGRD METER/RANGE/PPM                  .5/ 12/    .47
  CO2 SAMPLE METER/RANGE/PCT                73.1/ 11/  .6245
  CO2 BCKGRD METER/RANGE/PCT                 7.4/ 11/  .0433
  NOX SAMPLE METER/RANGE/PPM (D)              .5/ 73/  39.65
  NOX BCKGRD METER/RANGE/PPM                  .4/  2/    .41

  DILUTION FACTOR                                 21.86
  HC  CONCENTRATION PPM                            3.23
  CO  CONCENTRATION PPM                           10.49
  CO2 CONCENTRATION PCT                           .5831
  NOX CONCENTRATION PPM                           38.64

  HC  MASS GRAMS                                   1.413
  CO  MASS GRAMS                                   8.761
  CO2 MASS GRAMS                                7655.11
  NOX MASS GRAMS                                  52.089
  FUEL  KG (LB)                              2.558 (  5.64)
  KW HR (HP HR)                               8.99 ( 12.05)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .157(   .117) (   .12) (CONT)     90 MM FLTR NUMBERS          2553.0-142  P90-
  BSCO   G/KW HR (G/HP HR)        .975(   .727) (   .73)            90 MM FLTR WT. GAINS (MG)      1.261         .000
  BSNOX  G/KW HR (G/HP HR)       5.797(  4.323) (  4.32) (CONT)     PARTICULATE GRAMS/TEST                  .692
  PART.  G/KW HR (G/HP HR)        .077(   .057) (   .06)
  BSFC  KG/KW HR (LB/HP HR)       .285(   .468)
  WORK     KW HR (HP HR)          8.99(  12.05)
  BSCO2  G/KW HR (G/HP HR)       852. (   635.)
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                                        EPA  COLD TRANS ENGINE EMISSION RESULTS            PROJECT NO. 08-7507-001

ENGINE  NUMBER                              TEST  D-C1           RUN                DIESEL   REE50    EM-2134-F
ENGINE MODEL  95 CUMMINS                    DATE 11/17/95   TIME 9:06               HCR 1.83  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                COMPUTER PROGRAM  HDT 3.4-R             H .126  C .819  O .055  X .000
ENGINE CYCLE   DIESEL                       CELL  7      BAG CART 1                 ENGINE OIL
ENGINE SERIAL  6B7AA5.9                     REE50

BAROMETER 742.4 MM HG (29.23 IN HG)    CVS:  76.0°F  RH 56. PCT  AH  76.4 GR/LB         ENGINE DEW PT. 13.9°C (57.1°F)
ENGINE AIR TEMP. 25.6°C (78.0°F)       ENGINE: RH 49. PCT  AH 10.2 G/KG ( 71.5 GR/LB)  NOX HUMIDITY C.F.  .991
                                       REFERENCE WORK  8.96 KW HR (12.02 HP HR)         DRY-TO-WET C.F.   .977
BAG RESULTS
  BAG NUMBER                                  1
  TIME SECONDS                             1207.6
  TOT. BLOWER RATE SCMM (SCFM)           33.42 (1180.1)
  TOT. 90MM RATE SCMM (SCFM)               .07 ( 2.30)
  TOT. 20X20 RATE SCMM (SCFM)             1.50 ( 53.0)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)        .09 ( 3.08)
  TOTAL FLOW STD. CU. METRES(SCF)        706.0 ( 24928.)

  HC  SAMPLE METER/RANGE/PPM              .1/ 76/  10.17
  HC  BCKGRD METER/RANGE/PPM              .1/ 76/   4.65
  CO  SAMPLE METER/RANGE/PPM            21.9/ 12/  21.17
  CO  BCKGRD METER/RANGE/PPM              .8/ 12/    .76
  CO2 SAMPLE METER/RANGE/PCT            76.3/ 11/  .6634
  CO2 BCKGRD METER/RANGE/PCT             8.1/ 11/  .0476
  NOX SAMPLE METER/RANGE/PPM (D)          .5/ 73/  41.56
  NOX BCKGRD METER/RANGE/PPM              .4/  2/    .41

  DILUTION FACTOR                             20.54
  HC  CONCENTRATION PPM                        5.75
  CO  CONCENTRATION PPM                       19.82
  CO2 CONCENTRATION PCT                       .6181
  NOX CONCENTRATION PPM                       40.19

  HC  MASS GRAMS                               2.473
  CO  MASS GRAMS                              16.287
  CO2 MASS GRAMS                            7982.72
  NOX MASS GRAMS                              53.770
  FUEL  KG (LB)                          2.672 (  5.89)
  KW HR (HP HR)                           9.14 ( 12.26)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .270(   .202) (   .20) (CONT)      90 MM FLTR NUMBERS           2554.0-143  P90-
  BSCO   G/KW HR (G/HP HR)       1.782(  1.328) (  1.33)             90 MM FLTR WT. GAINS (MG)      2.270           .000
  BSNOX  G/KW HR (G/HP HR)       5.881(  4.386) (  4.39) (CONT)      PARTICULATE GRAMS/TEST               1.220
  PART.  G/KW HR (G/HP HR)        .133(   .100) (   .10)
  BSFC  KG/KW HR (LB/HP HR)       .292(   .480)
  WORK     KW HR (HP HR)          9.14(  12.26)
  BSCO2  G/KW HR (G/HP HR)       873. (   651.)
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                                        EPA  COLD TRANS ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                   TEST  D-C1            RUN                  DIESEL   REE50    EM-2134-F
ENGINE MODEL  95 CUMMINS                         DATE 11/17/95   TIME 9:06                  HCR 1.83  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6                    COMPUTER PROGRAM  HDT 3.4-R                H .126  C .819  O .055  X .000
ENGINE CYCLE   DIESEL                            CELL  7      BAG CART 1                    ENGINE OIL
ENGINE SERIAL  6B7AA5.9                          REE50

BAROMETER 742.4 MM HG (29.23 IN HG)     CVS:  76.0°F  RH 56. PCT  AH  76.4 GR/LB            ENGINE DEW PT. 13.9°C (57.1°F)
ENGINE AIR TEMP. 25.6°C (78.0°F)        ENGINE: RH 49. PCT  AH 10.2 G/KG ( 71.5 GR/LB)      NOX HUMIDITY C.F.   .991
                                        REFERENCE WORK  8.96 KW HR (12.02 HP HR)            DRY-TO-WET C.F.   .977

                          SAMPLE                BACKGROUND
  FORMALDEHYDE
    PPM                    .406                    .002
    MASS  MG             347.76
  ACETALDEHYDE
    PPM                    .100                    .002
    MASS  MG             124.13
  ACROLEIN
    PPM                    .018                    .005
    MASS  MG              21.25
  ACETONE
    PPM                    .014                    .007
    MASS  MG              11.55
  PROPIONALDEHYDE
    PPM                    .002                    .000
    MASS  MG               2.64
  CROTONALDEHYDE
    PPM                    .011                    .000
    MASS  MG              21.92
  ISOBUTYR+MEK
    PPM                    .008                    .000
    MASS  MG              16.83
  BENZALDEHYDE
    PPM                    .002                    .000
    MASS  MG               7.02
  HEXANALDEHYDE
    PPM                    .003                    .000
    MASS  MG               8.56

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR           28.365          CROTONALD.    MG/HP-HR              1.788
              ACETALDEHYDE MG/HP-HR           10.125          ISOBUTYR+MEK  MG/HP-HR              1.373
              ACROLEIN     MG/HP-HR            1.734          BENZALDEHYDE  MG/HP-HR               .572
              ACETONE      MG/HP-HR             .942          HEXANALDEHYDE MG/HP-HR               .698
              PROPIONALD.  MG/HP-HR             .216
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                              SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                        EPA  HOT TRANS  ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                    TEST  D-H1            RUN              DIESEL   REE50    EM-2134-F
ENGINE MODEL  95 CUMMINS                          DATE 11/17/95    TIME 9:46             HCR 1.83  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                      COMPUTER PROGRAM  HDT 3.4-R            H .126  C .819  O .055  X .000
ENGINE CYCLE   DIESEL                             CELL  7       BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                           REE50

BAROMETER 742.4 MM HG (29.23 IN HG)      CVS:  75.0°F  RH 55. PCT  AH  73.1 GR/LB        ENGINE DEW PT. 13.9°C (57.0°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)         ENGINE: RH 45. PCT  AH 10.2 G/KG ( 71.2 GR/LB)  NOX HUMIDITY C.F.  .990
                                         REFERENCE WORK  8.96 KW HR (12.02 HP HR)        DRY-TO-WET C.F.   .978
BAG RESULTS
  BAG NUMBER                                        1
  TIME SECONDS                                   1207.6
  TOT. BLOWER RATE SCMM (SCFM)                33.72 (1190.6)
  TOT. 90MM RATE SCMM (SCFM)                    .06 (  2.29)
  TOT. 20X20 RATE SCMM (SCFM)                  1.50 ( 53.1)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)             .09 ( 3.07)
  TOTAL FLOW STD. CU. METRES(SCF)             711.9 ( 25138.)

  HC  SAMPLE METER/RANGE/PPM                    .1/ 76/   9.04
  HC  BCKGRD METER/RANGE/PPM                    .1/ 76/   4.69
  CO  SAMPLE METER/RANGE/PPM                  16.2/ 12/  15.58
  CO  BCKGRD METER/RANGE/PPM                    .7/ 12/    .66
  CO2 SAMPLE METER/RANGE/PCT                  73.1/ 11/  .6245
  CO2 BCKGRD METER/RANGE/PCT                   8.3/ 11/  .0489
  NOX SAMPLE METER/RANGE/PPM (D)                .5/ 73/  39.47
  NOX BCKGRD METER/RANGE/PPM                    .7/  2/    .72

  DILUTION FACTOR                                   21.84
  HC  CONCENTRATION PPM                              4.56
  CO  CONCENTRATION PPM                             14.50
  CO2 CONCENTRATION PCT                             .5778
  NOX CONCENTRATION PPM                             37.90

  HC  MASS GRAMS                                    1.981
  CO  MASS GRAMS                                   12.018
  CO2 MASS GRAMS                                 7525.79
  NOX MASS GRAMS                                   51.095
  FUEL  KG (LB)                               2.517 (  5.55)
  KW HR (HP HR)                                9.08 ( 12.17)

TOTAL RESULTS
  BSHC  G/KW HR (G/HP HR)       .218(   .163) (   .16) (CONT)     90 MM FLTR NUMBERS          2572.0-164  P90-
  BSCO  G/KW HR (G/HP HR)      1.324(   .988) (   .99)            90 MM FLTR WT. GAINS (MG)      2.026          .000
  BSNOX  G/KW HR (G/HP HR)     5.630(  4.198) (  4.20) (CONT)     PARTICULATE GRAMS/TEST                1.103
  PART.  G/KW HR (G/HP HR)      .122(   .091) (   .09)
  BSFC  KG/KW HR (LB/HP HR)     .277(   .456)
  WORK     KW HR (HP HR)        9.08(  12.17)
  BSCO2  G/KW HR (G/HP HR)      829. (   618.)
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                              SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                        EPA  HOT TRANS  ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                    TEST  D-H1           RUN              DIESEL   REE50    EM-2134-F
ENGINE MODEL  95 CUMMINS                          DATE 11/17/95   TIME 9:46             HCR 1.83  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                      COMPUTER PROGRAM  HDT 3.4-R           H .126  C .819  O .055  X .000
ENGINE CYCLE   DIESEL                             CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                           REE50

BAROMETER 742.4 MM HG (29.23 IN HG)      CVS:  75.0°F  RH 55. PCT  AH  73.1 GR/LB       ENGINE DEW PT. 13.9°C (57.0°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)         ENGINE: RH 45. PCT  AH 10.2 G/KG ( 71.2 GR/LB) NOX HUMIDITY C.F.  .990
                                         REFERENCE WORK  8.96 KW HR (12.02 HP HR)       DRY-TO-WET C.F.   .978

                          SAMPLE               BACKGROUND
  FORMALDEHYDE
    PPM                     .282                 .002
    MASS  MG              243.30
  ACETALDEHYDE
    PPM                     .071                 .002
    MASS  MG               88.11
  ACROLEIN
    PPM                     .015                 .005
    MASS  MG               16.52
  ACETONE
    PPM                     .014                 .007
    MASS  MG               12.18
  PROP
    PPM                     .004                 .000
    MASS  MG                7.48
  CROTONALD.
    PPM                     .000                 .000
    MASS  MG                 .00
  ISOBUTYR+MEK
    PPM                     .007                 .000
    MASS  MG               14.75
  BENZALDEHYDE
    PPM                     .001                 .000
    MASS  MG                3.64
  HEXANALDEHYDE
    PPM                     .000                 .000
    MASS  MG                 .00

TOTAL RESULTS
             FORMALDEHYDE MG/HP-HR              19.992        CROTONALD.    MG/HP-HR              .000
             ACETALDEHYDE MG/HP-HR               7.240        ISOBUTYR+MEK  MG/HP-HR             1.212
             ACROLEIN     MG/HP-HR               1.357        BENZALDEHYDE  MG/HP-HR              .299
             ACETONE      MG/HP-HR               1.001        HEXANALDEHYDE MG/HP-HR              .000
             PROPIONALD.  MG/HP-HR                .615
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                         SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                  EPA  COMPOSITE  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                   TEST  D-H1            RUN         DIESEL   REE50    EM-2134-F
ENGINE MODEL  95 CUMMINS                         DATE 11/17/95   TIME 9:46         HCR 1.83  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                     COMPUTER PROGRAM  HDT 3.4-R       H .126  C .819  O .055  X .000
ENGINE CYCLE   DIESEL                            CELL  7      BAG CART 1           ENGINE OIL
ENGINE SERIAL  6B7AA5.9                          REE50

BAROMETER 742.4 MM HG (29.23 IN HG)     CVS:  75.0°F  RH 55. PCT  AH  73.1 GR/LB          ENGINE DEW PT. 13.9°C (57.0°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)        ENGINE: RH 45. PCT  AH 10.2 G/KG ( 71.2 GR/LB)  NOX HUMIDITY C.F.  .990
                                        REFERENCE WORK  8.96 KW HR (12.02 HP HR)        DRY-TO-WET C.F.   .978


  BSHC   G/KW HR (G/HP HR)      .226(   .168) (   .17) (CONT)
  BSCO   G/KW HR (G/HP HR)     1.390(  1.037) (  1.04)
  BSNOX  G/KW HR (G/HP HR)     5.666(  4.225) (  4.23) (CONT)
  PART.  G/KW HR (G/HP HR)      .123(   .092) (   .09)
  BSFC  KG/KW HR (LB/HP HR)     .279(   .459)
  WORK      KW HR (HP HR)       9.08(  12.18)
  BSCO2  G/KW HR (G/HP HR)      836. (   623.)
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                               SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                           EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                  TEST  D-H2            RUN                DIESEL   REE50    EM-2134-F
ENGINE MODEL  95 CUMMINS                        DATE 11/17/95   TIME 10:26               HCR 1.83  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6                   COMPUTER PROGRAM  HDT 3.4-R              H .126  C .819  O .055  X .000
ENGINE CYCLE   DIESEL                           CELL  7      BAG CART 1                  ENGINE OIL
ENGINE SERIAL  6B7AA5.9                         REE50

BAROMETER 742.7 MM HG (29.24 IN HG)     CVS:  76.0°F  RH 52. PCT  AH  71.4 GR/LB         ENGINE DEW PT. 13.8°C (56.9°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)        ENGINE: RH 44. PCT  AH 10.1 G/KG ( 70.9 GR/LB)  NOX HUMIDITY C.F.  .989
                                        REFERENCE WORK  8.96 KW HR (12.02 HP HR)         DRY-TO-WET C.F.   .978
BAG RESULTS
  BAG NUMBER                                    1
  TIME SECONDS                               1207.9
  TOT. BLOWER RATE SCMM (SCFM)            33.73 (1191.1)
  TOT. 90MM RATE SCMM (SCFM)                .07 ( 2.30)
  TOT. 20X20 RATE SCMM (SCFM)              1.50 ( 52.9)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)         .09 ( 3.06)
  TOTAL FLOW STD. CU. METRES(SCF)         712.3 ( 25150.)

  HC  SAMPLE METER/RANGE/PPM                .1/ 76/   9.09
  HC  BCKGRD METER/RANGE/PPM                .1/ 76/   4.77
  CO  SAMPLE METER/RANGE/PPM              16.1/ 12/  15.49
  CO  BCKGRD METER/RANGE/PPM                .9/ 12/    .85
  CO2 SAMPLE METER/RANGE/PCT              72.5/ 11/  .6173
  CO2 BCKGRD METER/RANGE/PCT               8.2/ 11/  .0483
  NOX SAMPLE METER/RANGE/PPM (D)            .5/ 73/  39.22
  NOX BCKGRD METER/RANGE/PPM                .3/  1/    .08

  DILUTION FACTOR                               22.09
  HC  CONCENTRATION PPM                          4.54
  CO  CONCENTRATION PPM                         14.24
  CO2 CONCENTRATION PCT                         .5712
  NOX CONCENTRATION PPM                         38.29

  HC  MASS GRAMS                                 1.969
  CO  MASS GRAMS                                11.812
  CO2 MASS GRAMS                              7443.41
  NOX MASS GRAMS                                51.605
  FUEL  KG (LB)                           2.489 (  5.49)
  KW HR (HP HR)                            9.03 ( 12.11)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .218(   .163) (   .16) (CONT)     90 MM FLTR NUMBERS          2573.0-165  P90-
  BSCO   G/KW HR (G/HP HR)       1.308(   .975) (   .98)            90 MM FLTR WT. GAINS (MG)     1.995          .000
  BSNOX  G/KW HR (G/HP HR)       5.715(  4.261) (  4.26) (CONT)     PARTICULATE GRAMS/TEST              1.086
  PART.  G/KW HR (G/HP HR)        .120(   .090) (   .09)
  BSFC  KG/KW HR (LB/HP HR)       .276(   .453)
  WORK      KW HR (HP HR)         9.03(  12.11)
  BSCO2  G/KW HR (G/HP HR)        824. (   615.)
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                                   EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                              TEST  E-C1           RUN               DIESEL   RME50    EM-2136-F
ENGINE MODEL  95 CUMMINS                    DATE 11/21/95   TIME                   HCR 1.86  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6               COMPUTER PROGRAM  HDT 3.4-R            H .128  C .821  O .051  X .000
ENGINE CYCLE   DIESEL                       CELL  7       BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                     RME50

BAROMETER 748.0 MM HG (29.45 IN HG)    CVS:  74.0°F  RH 47. PCT  AH  59.9 GR/LB           ENGINE DEW PT. 13.5°C (56.3°F)
ENGINE AIR TEMP. 25.6°C (78.0°F)       ENGINE: RH 47. PCT  AH  9.8 G/KG ( 68.9 GR/LB)  NOX HUMIDITY C.F.  .984
                                       REFERENCE WORK  8.95 KW HR (12.00 HP HR)        DRY-TO-WET C.F.   .980
BAG RESULTS
  BAG NUMBER                               1
  TIME SECONDS                          1207.1
  TOT. BLOWER RATE SCMM (SCFM)        33.69 (1189.4)
  TOT. 90MM RATE SCMM (SCFM)            .07 ( 2.30)
  TOT. 20X20 RATE SCMM (SCFM)          1.50 ( 53.1)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)     .09 ( 3.12)
  TOTAL FLOW STD. CU. METRES(SCF)     711.0 ( 25106.)

  HC  SAMPLE METER/RANGE/PPM            .1/ 76/   9.63
  HC  BCKGRD METER/RANGE/PPM            .1/ 76/   4.55
  CO  SAMPLE METER/RANGE/PPM          19.6/ 12/  18.91
  CO  BCKGRD METER/RANGE/PPM            .7/ 12/    .66
  CO2 SAMPLE METER/RANGE/PCT          74.7/ 11/  .6438
  CO2 BCKGRD METER/RANGE/PCT           8.6/ 11/  .0507
  NOX SAMPLE METER/RANGE/PPM (D)        .5/ 73/  42.43
  NOX BCKGRD METER/RANGE/PPM            .6/  2/    .62

  DILUTION FACTOR                          21.05
  HC  CONCENTRATION PPM                     5.30
  CO  CONCENTRATION PPM                    17.77
  CO2 CONCENTRATION PCT                    .5955
  NOX CONCENTRATION PPM                    41.01

  HC  MASS GRAMS                           2.290
  CO  MASS GRAMS                          14.709
  CO2 MASS GRAMS                         7745.35
  NOX MASS GRAMS                          54.885
  FUEL  KG (LB)                       2.585 (  5.70)
  KW HR (HP HR)                        9.17 ( 12.30)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)      .250(   .186) (   .19) (CONT)     90 MM FLTR NUMBERS          2574.0-170  P90-
  BSCO   G/KW HR (G/HP HR)     1.604(  1.196) (  1.20)            90 MM FLTR WT. GAINS (MG)     2.129          .000
  BSNOX  G/KW HR (G/HP HR)     5.984(  4.462) (  4.46) (CONT)     PARTICULATE GRAMS/TEST              1.155
  PART.  G/KW HR (G/HP HR)      .126(   .094) (   .09)
  BSFC  KG/KW HR (LB/HP HR)     .282(   .463)
  WORK      KW HR (HP HR)       9.17(  12.30)
  BSCO2  G/KW HR (G/HP HR)      844. (  630.)
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                    SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                            EPA  COLD TRANS ENGINE EMISSION RESULTS            PROJECT NO. 08-7507-001

ENGINE  NUMBER                              TEST  E-C1          RUN             DIESEL   RME50    EM-2136-F
ENGINE MODEL  95 CUMMINS                    DATE 11/21/95   TIME                HCR 1.86  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                COMPUTER PROGRAM  HDT 3.4-R         H .128   C .821   O .051   X .000
ENGINE CYCLE   DIESEL                       CELL  7       BAG CART 1            ENGINE OIL
ENGINE SERIAL  6B7AA5.9                     RME50

BAROMETER 748.0 MM HG (29.45 IN HG)    CVS:  74.0°F  RH 47. PCT  AH  59.9 GR/LB         ENGINE DEW PT. 13.5°C (56.3°F)
ENGINE AIR TEMP. 25.6°C (78.0°F)       ENGINE: RH 47. PCT  AH  9.8 G/KG ( 68.9 GR/LB)  NOX HUMIDITY C.F.   .984
                                       REFERENCE WORK  8.95 KW HR (12.00 HP HR)        DRY-TO-WET C.F.    .980

                         SAMPLE              BACKGROUND
 FORMALDEHYDE
   PPM                     .381                 .001
   MASS  MG              331.03
 ACETALDEHYDE
   PPM                     .098                 .006
   MASS  MG              118.04
 ACROLEIN
   PPM                     .020                 .000
   MASS  MG               33.07
 ACETONE
   PPM                     .015                 .003
   MASS  MG               20.97
 PROPIONALDEHYDE
   PPM                     .014                 .000
   MASS  MG               23.50
 CROTONALDEHYDE
   PPM                     .009                 .000
   MASS  MG               18.66
 ISOBUTYR+MEK
   PPM                     .011                 .000
   MASS  MG               23.08
 BENZALDEHYDE
   PPM                     .006                 .000
   MASS  MG               19.33
 HEXANALDEHYDE
   PPM                     .007                 .001
   MASS  MG               15.39

TOTAL RESULTS
             FORMALDEHYDE MG/HP-HR           26.913          CROTONALD.    MG/HP-HR              1.517
             ACETALDEHYDE MG/HP-HR            9.597          ISOBUTYR+MEK  MG/HP-HR              1.877
             ACROLEIN     MG/HP-HR            2.689          BENZALDEHYDE  MG/HP-HR              1.572
             ACETONE      MG/HP-HR            1.705          HEXANALDEHYDE MG/HP-HR              1.251
             PROPIONALD.  MG/HP-HR            1.911
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                      SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                             EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                               TEST  E-H1           RUN          DIESEL   RME50    EM-2136-F
ENGINE MODEL  95 CUMMINS                     DATE 11/21/95   TIME              HCR 1.86  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                 COMPUTER PROGRAM  HDT 3.4-R       H .128  C .821  O .051  X .000
ENGINE CYCLE   DIESEL                        CELL  7      BAG CART 1           ENGINE OIL
ENGINE SERIAL  6B7AA5.9                      RME50

BAROMETER 747.8 MM HG (29.44 IN HG)      CVS:  74.0°F  RH 47. PCT  AH  59.9 GR/LB      ENGINE DEW PT. 13.5°C (56.3°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)         ENGINE: RH 43. PCT  AH  9.8 G/KG ( 68.9 GR/LB)  NOX HUMIDITY C.F.  .984
                                         REFERENCE WORK  8.95 KW HR (12.00 HP HR)        DRY-TO-WET C.F.   .980
BAG RESULTS
  BAG NUMBER                                   1
  TIME SECONDS                              1207.1
  TOT. BLOWER RATE SCMM (SCFM)             33.73 (1190.9)
  TOT. 90MM RATE SCMM (SCFM)                 .07 ( 2.31)
  TOT. 20X20 RATE SCMM (SCFM)               1.52 ( 53.7)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)          .09 ( 3.14)
  TOTAL FLOW STD. CU. METRES(SCF)          712.2 ( 25148.)

  HC  SAMPLE METER/RANGE/PPM                .1/ 76/   8.49
  HC  BCKGRD METER/RANGE/PPM                .1/ 76/   4.44
  CO  SAMPLE METER/RANGE/PPM              14.8/ 12/  14.22
  CO  BCKGRD METER/RANGE/PPM                .6/ 12/    .57
  CO2 SAMPLE METER/RANGE/PCT              73.9/ 11/  .6341
  CO2 BCKGRD METER/RANGE/PCT               8.9/ 11/  .0526
  NOX SAMPLE METER/RANGE/PPM (D)            .5/ 73/  40.16
  NOX BCKGRD METER/RANGE/PPM                .6/  2/    .62

  DILUTION FACTOR                              21.39
  HC  CONCENTRATION PPM                         4.26
  CO  CONCENTRATION PPM                        13.30
  CO2 CONCENTRATION PCT                        .5839
  NOX CONCENTRATION PPM                        38.79

  HC  MASS GRAMS                               1.844
  CO  MASS GRAMS                              11.024
  CO2 MASS GRAMS                             7608.44
  NOX MASS GRAMS                              52.002
  FUEL  KG (LB)                            2.538 (  5.59)
  KW HR (HP HR)                             9.07 ( 12.16)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .203(   .152) (   .15) (CONT)     90 MM FLTR NUMBERS         2533.0-171  P90-
  BSCO   G/KW HR (G/HP HR)       1.216(   .907) (   .91)            90 MM FLTR WT. GAINS (MG)     1.944          .000
  BSNOX  G/KW HR (G/HP HR)       5.735(  4.276) (  4.28) (CONT)     PARTICULATE GRAMS/TEST             1.054
  PART.  G/KW HR (G/HP HR)        .116(   .087) (   .09)
  BSFC  KG/KW HR (LB/HP HR)       .280(   .460)
  WORK      KW HR (HP HR)         9.07(  12.16)
  BSCO2  G/KW HR (G/HP HR)        839. (   626.)
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                         SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                  EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                TEST  E-H1           RUN              DIESEL   RME50    EM-2136-F
ENGINE MODEL  95 CUMMINS                      DATE 11/21/95  TIME                   HCR 1.86  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                  COMPUTER PROGRAM  HDT 3.4-R           H .128  C .821  O .051  X .000
ENGINE CYCLE   DIESEL                         CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                       RME50

BAROMETER 747.8 MM HG (29.44 IN HG)     CVS:  74.0°F  RH 47. PCT  AH  59.9 GR/LB        ENGINE DEW PT. 13.5°C (56.3°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)        ENGINE: RH 43. PCT  AH  9.8 G/KG ( 68.9 GR/LB)  NOX HUMIDITY C.F.  .984
                                        REFERENCE WORK  8.95 KW HR (12.00 HP HR)        DRY-TO-WET C.F.   .980

                        SAMPLE              BACKGROUND
  FORMALDEHYDE
    PPM                  .258                 .001
    MASS  MG           224.68
  ACETALDEHYDE
    PPM                  .068                 .006
    MASS  MG            80.09
  ACROLEIN
    PPM                  .013                 .000
    MASS  MG            21.14
  ACETONE
    PPM                  .011                 .003
    MASS  MG            13.91
  PROP
    PPM                  .010                 .000
    MASS  MG            17.66
  CROTONALD.
    PPM                  .008                 .000
    MASS  MG            16.49
  ISOBUTYR+MEK
    PPM                  .008                 .000
    MASS  MG            17.63
  BENZALDEHYDE
    PPM                  .005                 .000
    MASS  MG            15.15
  HEXANALDEHYDE
    PPM                  .014                 .001
    MASS  MG            36.59

TOTAL RESULTS
             FORMALDEHYDE MG/HP-HR              18.477         CROTONALD.    MG/HP-HR            1.356
             ACETALDEHYDE MG/HP-HR               6.586         ISOBUTYR+MEK  MG/HP-HR            1.450
             ACROLEIN     MG/HP-HR               1.739         BENZALDEHYDE  MG/HP-HR            1.246
             ACETONE      MG/HP-HR               1.144         HEXANALDEHYDE MG/HP-HR            3.009
             PROPIONALD.  MG/HP-HR               1.453
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                         SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                    EPA  HOT TRANS  ENGINE EMISSION RESULTS            PROJECT NO. 08-7507-001

ENGINE  NUMBER                                 TEST  E-H2           RUN            DIESEL   RME50    EM-2136-F
ENGINE MODEL  95 CUMMINS                       DATE 11/21/95   TIME 11:19          HCR 1.86  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                   COMPUTER PROGRAM  HDT 3.3-R         H .128  C .821  O .051  X .000
ENGINE CYCLE   DIESEL                          CELL  7       BAG CART 1            ENGINE OIL
ENGINE SERIAL  6B7AA5.9                        RME50

BAROMETER 747.5 MM HG (29.43 IN HG)       CVS:  74.0°F  RH 51.0 PCT  AH  64.6 GR/LB    ENGINE DEW PT. 13.5°C (56.3°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)          ENGINE ABS. HUM.  9.8 G/KG ( 68.9 GR/LB)     NOX HUMIDITY C.F.  .984
                                                                                       DRY-TO-WET C.F.   .979
BAG RESULTS
  BAG NUMBER                                     1
  TIME SECONDS                                1207.1
  TOT. BLOWER RATE SCMM (SCFM)              34.01 (1200.8)
  TOT. 90MM RATE SCMM (SCFM)                  .07 ( 2.33)
  TOT. 20X20 RATE SCMM (SCFM)                1.51 ( 53.5)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)           .09 ( 3.09)
  TOTAL FLOW STD. CU. METRES(SCF)           717.7 ( 25343.)

  HC  SAMPLE METER/RANGE/PPM                  .1/ 76/   8.84
  HC  BCKGRD METER/RANGE/PPM                  .1/ 76/   4.80
  CO  SAMPLE METER/RANGE/PPM                15.4/ 12/  14.80
  CO  BCKGRD METER/RANGE/PPM                  .4/ 12/    .38
  CO2 SAMPLE METER/RANGE/PCT                73.3/ 11/  .6269
  CO2 BCKGRD METER/RANGE/PCT                 8.7/ 11/  .0514
  NOX SAMPLE METER/RANGE/PPM (D)              .5/ 73/  39.68
  NOX BCKGRD METER/RANGE/PPM                  .4/  2/    .41

  DILUTION FACTOR                               21.63
  HC  CONCENTRATION PPM                          4.26
  CO  CONCENTRATION PPM                         14.03
  CO2 CONCENTRATION PCT                         .5779
  NOX CONCENTRATION PPM                         38.47

  HC  MASS GRAMS                                 1.860
  CO  MASS GRAMS                                11.720
  CO2 MASS GRAMS                              7587.84
  NOX MASS GRAMS                                51.984
  FUEL  KG (LB)                             2.531 (  5.58)
  KW HR (HP HR)                              9.08 ( 12.18)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)      .205(  .153) (  .15) (CONT)      90 MM FILTER NUMBERS          2534.0-  P90-
  BSCO   G/KW HR (G/HP HR)     1.290(  .962) (  .96)             90 MM FILTER WT. GAINS (MG)    1.925    .000
  BSNOX  G/KW HR (G/HP HR)     5.723( 4.268) ( 4.27) (CONT)      PARTICULATE GRAMS/TEST            1.040
  PART.  G/KW HR (G/HP HR)      .114(  .085) (  .09)
  BSFC  KG/KW HR (LB/HP HR)      .279(   .458)
  WORK      KW HR (HP HR)        9.08(  12.18)
  BSCO2  G/KW HR (G/HP HR)      835. (   623.)
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                    SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                           EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                         TEST  EC-C1          RUN              DIESEL   RME50    EM-2136-F
ENGINE MODEL  95 CUMMINS               DATE 11/22/95   TIME                  HCR 1.86  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6           COMPUTER PROGRAM  HDT 3.4-R           H .128  C .821  O .051  X .000
ENGINE CYCLE   DIESEL                  CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                RME50                                 CATALYST

BAROMETER 744.2 MM HG (29.30 IN HG)  CVS:  73.0°F  RH 54. PCT  AH  66.7 GR/LB        ENGINE DEW PT. 13.4°C (56.1°F)
ENGINE AIR TEMP. 25.6°C (78.0°F)     ENGINE: RH 47. PCT  AH  9.8 G/KG ( 68.7 GR/LB)  NOX HUMIDITY C.F.  .984
                                     REFERENCE WORK  8.99 KW HR (12.06 HP HR)        DRY-TO-WET C.F.   .979
BAG RESULTS
  BAG NUMBER                                  1
  TIME SECONDS                             1207.1
  TOT. BLOWER RATE SCMM (SCFM)           33.91 (1197.5)
  TOT. 90MM RATE SCMM (SCFM)               .07 ( 2.31)
  TOT. 20X20 RATE SCMM (SCFM)             1.49 ( 52.6)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)        .09 ( 3.11)
  TOTAL FLOW STD. CU. METRES(SCF)        715.3 ( 25257.)

  HC  SAMPLE METER/RANGE/PPM              .1/ 76/   7.78
  HC  BCKGRD METER/RANGE/PPM              .0/ 76/   3.92
  CO  SAMPLE METER/RANGE/PPM            16.0/ 12/  15.39
  CO  BCKGRD METER/RANGE/PPM              .8/ 12/    .76
  CO2 SAMPLE METER/RANGE/PCT            74.9/ 11/  .6462
  CO2 BCKGRD METER/RANGE/PCT             9.1/ 11/  .0539
  NOX SAMPLE METER/RANGE/PPM (D)          .5/ 73/  41.82
  NOX BCKGRD METER/RANGE/PPM              .6/  2/    .62

  DILUTION FACTOR                             20.99
  HC  CONCENTRATION PPM                        4.05
  CO  CONCENTRATION PPM                       14.22
  CO2 CONCENTRATION PCT                       .5949
  NOX CONCENTRATION PPM                       40.35

  HC  MASS GRAMS                              1.760
  CO  MASS GRAMS                             11.843
  CO2 MASS GRAMS                            7785.20
  NOX MASS GRAMS                             54.304
  FUEL  KG (LB)                          2.597 (  5.72)
  KW HR (HP HR)                           9.11 ( 12.22)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)      .193(   .144) (   .14) (CONT)    90 MM FLTR NUMBERS          2582.0-173  P90-
  BSCO   G/KW HR (G/HP HR)     1.300(   .969) (   .97)           90 MM FLTR WT. GAINS (MG)     1.335          .000
  BSNOX  G/KW HR (G/HP HR)     5.959(  4.444) (  4.44) (CONT)    PARTICULATE GRAMS/TEST                 .725
  PART.  G/KW HR (G/HP HR)      .080(   .059) (   .06)
  BSFC  KG/KW HR (LB/HP HR)     .285(   .468)
  WORK      KW HR (HP HR)       9.11(  12.22)
  BSCO2  G/KW HR (G/HP HR)      854. (   637.)
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                              SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                          EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                       TEST  EC-C1          RUN                DIESEL   RME50    EM-2136-F
ENGINE MODEL  95 CUMMINS                             DATE 11/22/95   TIME                    HCR 1.86  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                         COMPUTER PROGRAM  HDT 3.4-R             H .128  C .821  O .051  X .000
ENGINE CYCLE   DIESEL                                CELL  7      BAG CART 1                 ENGINE OIL
ENGINE SERIAL  6B7AA5.9                              RME50                                   CATALYST

BAROMETER 744.2 MM HG (29.30 IN HG)     CVS:  73.0°F  RH 54. PCT  AH  66.7 GR/LB             ENGINE DEW PT. 13.4°C (56.1°F)
ENGINE AIR TEMP. 25.6°C (78.0°F)        ENGINE: RH 47. PCT  AH  9.8 G/KG ( 68.7 GR/LB)  NOX HUMIDITY C.F.  .984
                                        REFERENCE WORK  8.99 KW HR (12.06 HP HR)        DRY-TO-WET C.F.   .979

                          SAMPLE              BACKGROUND
  FORMALDEHYDE
    PPM                     .491                 .025
    MASS  MG              409.02
  ACETALDEHYDE
    PPM                     .147                 .004
    MASS  MG              183.71
  ACROLEIN
    PPM                     .018                 .000
    MASS  MG               29.91
  ACETONE
    PPM                     .026                 .006
    MASS  MG               35.00
  PROPIONALDEHYDE
    PPM                     .018                 .000
    MASS  MG               30.31
  CROTONALDEHYDE
    PPM                     .007                 .000
    MASS  MG               14.54
  ISOBUTYR+MEK
    PPM                     .013                 .000
    MASS  MG               28.22
  BENZALDEHYDE
    PPM                     .000                 .000
    MASS  MG                 .00
  HEXANALDEHYDE
    PPM                     .006                 .000
    MASS  MG               17.12

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR             33.471          CROTONALD.    MG/HP-HR             1.190
              ACETALDEHYDE MG/HP-HR             15.034          ISOBUTYR+MEK  MG/HP-HR             2.309
              ACROLEIN     MG/HP-HR              2.447          BENZALDEHYDE  MG/HP-HR              .000
              ACETONE      MG/HP-HR              2.864          HEXANALDEHYDE MG/HP-HR             1.401
              PROPIONALD.  MG/HP-HR              2.481
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                    SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                              EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                 TEST  EC-H1          RUN            DIESEL   RME50    EM-2136-F
ENGINE MODEL  95 CUMMINS                       DATE 11/22/95   TIME 10:09          HCR 1.86  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                   COMPUTER PROGRAM  HDT 3.4-R         H .128  C .821  O .051  X .000
ENGINE CYCLE   DIESEL                          CELL  7      BAG CART 1             ENGINE OIL
ENGINE SERIAL  6B7AA5.9                        RME50                               CATALYST

BAROMETER 744.0 MM HG (29.29 IN HG)    CVS:  73.0°F  RH 50. PCT  AH  62.0 GR/LB    ENGINE DEW PT. 13.7°C (56.6°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)       ENGINE: RH 43. PCT  AH 10.0 G/KG ( 70.0 GR/LB) NOX HUMIDITY C.F.  .987
                                       REFERENCE WORK  8.99 KW HR (12.06 HP HR)    DRY-TO-WET C.F.   .980
BAG RESULTS
  BAG NUMBER                                   1
  TIME SECONDS                              1207.7
  TOT. BLOWER RATE SCMM (SCFM)          33.88 (1196.4)
  TOT. 90MM RATE SCMM (SCFM)              .07 ( 2.30)
  TOT. 20X20 RATE SCMM (SCFM)            1.51 ( 53.2)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)       .09 ( 3.08)
  TOTAL FLOW STD. CU. METRES(SCF)       715.4 ( 25261.)

  HC  SAMPLE METER/RANGE/PPM              .1/ 76/   6.86
  HC  BCKGRD METER/RANGE/PPM              .0/ 76/   4.00
  CO  SAMPLE METER/RANGE/PPM            11.1/ 12/  10.62
  CO  BCKGRD METER/RANGE/PPM             1.1/ 12/   1.04
  CO2 SAMPLE METER/RANGE/PCT            73.5/ 11/  .6293
  CO2 BCKGRD METER/RANGE/PCT             8.6/ 11/  .0507
  NOX SAMPLE METER/RANGE/PPM (D)          .5/ 73/  40.28
  NOX BCKGRD METER/RANGE/PPM              .7/  2/    .72

  DILUTION FACTOR                              21.57
  HC  CONCENTRATION PPM                         3.05
  CO  CONCENTRATION PPM                         9.35
  CO2 CONCENTRATION PCT                        .5809
  NOX CONCENTRATION PPM                        38.79

  HC  MASS GRAMS                               1.325
  CO  MASS GRAMS                               7.783
  CO2 MASS GRAMS                             7602.63
  NOX MASS GRAMS                              52.390
  FUEL  KG (LB)                         2.533 (  5.59)
  KW HR (HP HR)                          9.10 ( 12.20)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .146(   .109) (   .11) (CONT)     90 MM FLTR NUMBERS          2562.0-191  P90-
  BSCO   G/KW HR (G/HP HR)       .856(   .638) (   .64)            90 MM FLTR WT. GAINS (MG)     1.220          .000
  BSNOX  G/KW HR (G/HP HR)      5.759(  4.294) (  4.29) (CONT)     PARTICULATE GRAMS/TEST                .665
  PART.  G/KW HR (G/HP HR)       .073(   .055) (   .05)
  BSFC  KG/KW HR (LB/HP HR)      .278(   .458)
  WORK       KW HR (HP HR)       9.10(  12.20)
  BSCO2  G/KW HR (G/HP HR)      836. (   623.)
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                                        EPA  HOT TRANS  ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                TEST  EC-H1          RUN               DIESEL   RME50    EM-2136-F
ENGINE MODEL  95 CUMMINS                      DATE 11/22/95   TIME 10:09             HCR 1.86  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                  COMPUTER PROGRAM  HDT 3.4-R            H .128  C .821  O .051  X .000
ENGINE CYCLE   DIESEL                         CELL  7      BAG CART 1                ENGINE OIL
ENGINE SERIAL  6B7AA5.9                       RME50                                  CATALYST

BAROMETER 744.0 MM HG (29.29 IN HG)     CVS:  73.0°F  RH 50. PCT  AH  62.0 GR/LB      ENGINE DEW PT. 13.7°C (56.6°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)        ENGINE: RH 43. PCT  AH 10.0 G/KG ( 70.0 GR/LB) NOX HUMIDITY C.F.  .987
                                        REFERENCE WORK  8.99 KW HR (12.06 HP HR)       DRY-TO-WET C.F.   .980

                          SAMPLE              BACKGROUND
 FORMALDEHYDE
   PPM                     .339                 .025
   MASS  MG              275.99
 ACETALDEHYDE
   PPM                     .103                 .004
   MASS  MG              126.85
 ACROLEIN
   PPM                     .011                 .000
   MASS  MG               18.07
 ACETONE
   PPM                     .020                 .006
   MASS  MG               25.00
 PROP
   PPM                     .014                 .000
   MASS  MG               23.57
 CROTONALD.
   PPM                     .003                 .000
   MASS  MG                5.79
 ISOBUTYR+MEK
   PPM                     .001                 .000
   MASS  MG                2.93
 BENZALDEHYDE
   PPM                     .000                 .000
   MASS  MG                 .00
 HEXANALDEHYDE
   PPM                     .000                 .000
   MASS  MG                 .00

TOTAL RESULTS
             FORMALDEHYDE MG/HP-HR           22.622        CROTONALD.    MG/HP-HR            .474
             ACETALDEHYDE MG/HP-HR           10.397        ISOBUTYR+MEK  MG/HP-HR            .240
             ACROLEIN     MG/HP-HR            1.481        BENZALDEHYDE  MG/HP-HR            .000
             ACETONE      MG/HP-HR            2.049        HEXANALDEHYDE MG/HP-HR            .000
             PROPIONALD.  MG/HP-HR            1.932
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                                 EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                              TEST  EC-H2          RUN               DIESEL   RME50    EM-2136-F
ENGINE MODEL  95 CUMMINS                    DATE 11/22/95   TIME 10:49             HCR 1.86   FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                COMPUTER PROGRAM  HDT 3.4-R            H .128   C .821   O .051   X .000
ENGINE CYCLE   DIESEL                       CELL  7      BAG CART 1                ENGINE OIL
ENGINE SERIAL  6B7AA5.9                     RME50                                  CATALYST

BAROMETER 743.5 MM HG (29.27 IN HG)      CVS:  74.0°F  RH 51. PCT  AH  65.1 GR/LB        ENGINE DEW PT. 13.8°C (56.9°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)         ENGINE: RH 44. PCT  AH 10.1 G/KG ( 70.8 GR/LB)  NOX HUMIDITY C.F.  .989
                                         REFERENCE WORK  8.99 KW HR (12.06 HP HR)        DRY-TO-WET C.F.   .979
BAG RESULTS
  BAG NUMBER                                   1
  TIME SECONDS                               1207.7
  TOT. BLOWER RATE SCMM (SCFM)            34.01 (1200.9)
  TOT. 90MM RATE SCMM (SCFM)                .07 ( 2.31)
  TOT. 20X20 RATE SCMM (SCFM)              1.51 ( 53.5)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)         .09 ( 3.06)
  TOTAL FLOW STD. CU. METRES(SCF)         718.1 ( 25358.)

  HC  SAMPLE METER/RANGE/PPM                .1/ 76/   6.74
  HC  BCKGRD METER/RANGE/PPM                .0/ 76/   3.93
  CO  SAMPLE METER/RANGE/PPM              11.5/ 12/  11.01
  CO  BCKGRD METER/RANGE/PPM               1.1/ 12/   1.04
  CO2 SAMPLE METER/RANGE/PCT              73.0/ 11/  .6233
  CO2 BCKGRD METER/RANGE/PCT               9.0/ 11/  .0532
  NOX SAMPLE METER/RANGE/PPM (D)            .5/ 73/  39.70
  NOX BCKGRD METER/RANGE/PPM                .7/  2/    .72

  DILUTION FACTOR                               21.78
  HC  CONCENTRATION PPM                          2.99
  CO  CONCENTRATION PPM                          9.72
  CO2 CONCENTRATION PCT                         .5725
  NOX CONCENTRATION PPM                         38.19

  HC  MASS GRAMS                                1.306
  CO  MASS GRAMS                                8.127
  CO2 MASS GRAMS                              7521.19
  NOX MASS GRAMS                               51.894
  FUEL  KG (LB)                           2.507 (  5.53)
  KW HR (HP HR)                            9.07 ( 12.16)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .144(   .107) (   .11) (CONT)     90 MM FLTR NUMBERS          2561.0-190  P90-
  BSCO   G/KW HR (G/HP HR)        .896(   .668) (   .67)            90 MM FLTR WT. GAINS (MG)     1.210          .000
  BSNOX  G/KW HR (G/HP HR)       5.723(  4.268) (  4.27) (CONT)     PARTICULATE GRAMS/TEST               .661
  PART.  G/KW HR (G/HP HR)        .073(   .054) (   .05)
  BSFC  KG/KW HR (LB/HP HR)       .276(   .454)
  WORK      KW HR (HP HR)         9.07(  12.16)
  BSCO2  G/KW HR (G/HP HR)       829. (   619.)
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                                    EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                               TEST  FC-C1          RUN             DIESEL   REE20    EM-2135-F
ENGINE MODEL  95 CUMMINS                     DATE 11/27/95   TIME 9:51            HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                 COMPUTER PROGRAM  HDT 3.4-R          H .132  C .848  O .020  X .000
ENGINE CYCLE   DIESEL                        CELL  7      BAG CART 1              ENGINE OIL
ENGINE SERIAL  6B7AA5.9                      REE20                                CATALYST

BAROMETER 734.8 MM HG (28.93 IN HG)     CVS:  74.0°F  RH 51. PCT  AH  66.1 GR/LB     ENGINE DEW PT. 13.4°C (56.1°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)        ENGINE: RH 45. PCT  AH  9.9 G/KG ( 69.6 GR/LB)  NOX HUMIDITY C.F.  .986
                                        REFERENCE WORK  9.11 KW HR (12.22 HP HR)     DRY-TO-WET C.F.   .979
BAG RESULTS
  BAG NUMBER                                  1
  TIME SECONDS                             1207.2
  TOT. BLOWER RATE SCMM (SCFM)           33.38 (1178.7)
  TOT. 90MM RATE SCMM (SCFM)               .06 ( 2.25)
  TOT. 20X20 RATE SCMM (SCFM)             1.48 ( 52.4)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)        .09 ( 3.09)
  TOTAL FLOW STD. CU. METRES(SCF)        704.5 ( 24878.)

  HC  SAMPLE METER/RANGE/PPM               .1/ 76/  10.10
  HC  BCKGRD METER/RANGE/PPM               .1/ 76/   4.45
  CO  SAMPLE METER/RANGE/PPM             20.7/ 12/  19.99
  CO  BCKGRD METER/RANGE/PPM               .2/ 12/    .19
  CO2 SAMPLE METER/RANGE/PCT             75.8/ 11/  .6573
  CO2 BCKGRD METER/RANGE/PCT              7.8/ 11/  .0458
  NOX SAMPLE METER/RANGE/PPM (D)           .5/ 73/  42.80
  NOX BCKGRD METER/RANGE/PPM               .8/  2/    .82

  DILUTION FACTOR                              20.48
  HC  CONCENTRATION PPM                         5.87
  CO  CONCENTRATION PPM                        19.23
  CO2 CONCENTRATION PCT                        .6137
  NOX CONCENTRATION PPM                        41.11

  HC  MASS GRAMS                                2.433
  CO  MASS GRAMS                               15.776
  CO2 MASS GRAMS                             7910.01
  NOX MASS GRAMS                               54.627
  FUEL  KG (LB)                          2.557 (  5.64)
  KW HR (HP HR)                           9.16 ( 12.28)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .266(   .198) (   .20) (CONT)     90 MM FLTR NUMBERS          2560.0-195  P90-
  BSCO   G/KW HR (G/HP HR)      1.723(  1.285) (  1.28)            90 MM FLTR WT. GAINS (MG)     1.598          .000
  BSNOX  G/KW HR (G/HP HR)      5.966(  4.448) (  4.45) (CONT)     PARTICULATE GRAMS/TEST                  .877
  PART.  G/KW HR (G/HP HR)       .096(   .071) (   .07)
  BSFC  KG/KW HR (LB/HP HR)      .279(   .459)
  WORK      KW HR (HP HR)        9.16(  12.28)
  BSCO2  G/KW HR (G/HP HR)      864. (   644.)
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                      SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                              EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                           TEST  FC-C1          RUN                DIESEL   REE20    EM-2135-F
ENGINE MODEL  95 CUMMINS                 DATE 11/27/95   TIME 9:51               HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6             COMPUTER PROGRAM  HDT 3.4-R             H .132  C .848  O .020  X .000
ENGINE CYCLE   DIESEL                    CELL  7      BAG CART 1                 ENGINE OIL
ENGINE SERIAL  6B7AA5.9                  REE20                                   CATALYST

BAROMETER 734.8 MM HG (28.93 IN HG)   CVS:  74.0°F  RH 51. PCT  AH  66.1 GR/LB     ENGINE DEW PT. 13.4°C (56.1°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)      ENGINE: RH 45. PCT  AH  9.9 G/KG ( 69.6 GR/LB) NOX HUMIDITY C.F.  .986
                                      REFERENCE WORK  9.11 KW HR (12.22 HP HR)       DRY-TO-WET C.F.   .979

                        SAMPLE              BACKGROUND
  FORMALDEHYDE
    PPM                  .608                  .005
    MASS  MG           519.59
  ACETALDEHYDE
    PPM                  .189                  .000
    MASS  MG           238.56
  ACROLEIN
    PPM                  .032                  .000
    MASS  MG            52.17
  ACETONE
    PPM                  .042                  .007
    MASS  MG            59.08
  PROPIONALDEHYDE
    PPM                  .027                  .004
    MASS  MG            38.26
  CROTONALDEHYDE
    PPM                  .008                  .000
    MASS  MG            16.20
  ISOBUTYR+MEK
    PPM                  .009                  .000
    MASS  MG            19.03
  BENZALDEHYDE
    PPM                  .011                  .000
    MASS  MG            33.29
  HEXANALDEHYDE
    PPM                  .021                  .000
    MASS  MG            61.63

TOTAL RESULTS
            FORMALDEHYDE MG/HP-HR          42.312          CROTONALD.     MG/HP-HR            1.319
            ACETALDEHYDE MG/HP-HR          19.427          ISOBUTYR+MEK  MG/HP-HR            1.550
            ACROLEIN     MG/HP-HR           4.248          BENZALDEHYDE  MG/HP-HR            2.711
            ACETONE      MG/HP-HR           4.811          HEXANALDEHYDE MG/HP-HR            5.018
            PROPIONALD.  MG/HP-HR           3.116
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                                        EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                TEST  FC-H1          RUN              DIESEL   REE20    EM-2135-F
ENGINE MODEL  95 CUMMINS                      DATE 11/27/95   TIME 10:31            HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                  COMPUTER PROGRAM  HDT 3.4-R           H .132  C .848  O .020  X .000
ENGINE CYCLE   DIESEL                         CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                       REE20                                 CATALYST

BAROMETER 735.1 MM HG (28.94 IN HG)     CVS:  74.0°F  RH 51. PCT  AH  66.0 GR/LB        ENGINE DEW PT. 13.8°C (56.8°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)        ENGINE: RH 45. PCT  AH 10.2 G/KG ( 71.4 GR/LB)  NOX HUMIDITY C.F.  .991
                                        REFERENCE WORK  9.11 KW HR (12.22 HP HR)        DRY-TO-WET C.F.   .979
BAG RESULTS
  BAG NUMBER                                  1
  TIME SECONDS                             1207.2
  TOT. BLOWER RATE SCMM (SCFM)          33.50 (1182.7)
  TOT. 90MM RATE SCMM (SCFM)              .06 ( 2.25)
  TOT. 20X20 RATE SCMM (SCFM)            1.51 ( 53.2)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)       .09 ( 3.10)
  TOTAL FLOW STD. CU. METRES(SCF)       707.3 ( 24974.)

  HC  SAMPLE METER/RANGE/PPM              .1/ 76/   9.23
  HC  BCKGRD METER/RANGE/PPM              .1/ 76/   4.91
  CO  SAMPLE METER/RANGE/PPM            13.6/ 12/  13.05
  CO  BCKGRD METER/RANGE/PPM              .1/ 12/    .09
  CO2 SAMPLE METER/RANGE/PCT            75.0/ 11/  .6474
  CO2 BCKGRD METER/RANGE/PCT             7.8/ 11/  .0458
  NOX SAMPLE METER/RANGE/PPM (D)          .5/ 73/  40.46
  NOX BCKGRD METER/RANGE/PPM              .6/  2/    .62

  DILUTION FACTOR                            20.81
  HC  CONCENTRATION PPM                       4.56
  CO  CONCENTRATION PPM                      12.58
  CO2 CONCENTRATION PCT                      .6039
  NOX CONCENTRATION PPM                      39.02

  HC  MASS GRAMS                              1.897
  CO  MASS GRAMS                             10.360
  CO2 MASS GRAMS                           7813.20
  NOX MASS GRAMS                             52.288
  FUEL  KG (LB)                         2.522 (  5.56)
  KW HR (HP HR)                          9.09 ( 12.19)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .209(   .156) (   .16) (CONT)     90 MM FLTR NUMBERS          2569.0-196  P90-
  BSCO   G/KW HR (G/HP HR)       1.140(   .850) (   .85)            90 MM FLTR WT. GAINS (MG)     1.439          .000
  BSNOX  G/KW HR (G/HP HR)       5.752(  4.289) (  4.29) (CONT)     PARTICULATE GRAMS/TEST                .795
  PART.  G/KW HR (G/HP HR)        .087(   .065) (   .07)
  BSFC  KG/KW HR (LB/HP HR)       .277(   .456)
  WORK     KW HR (HP HR)          9.09(  12.19)
  BSCO2  G/KW HR (G/HP HR)       860. (   641.)
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                                 SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                             EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                        TEST  FC-H1          RUN                DIESEL   REE20    EM-2135-F
ENGINE MODEL  95 CUMMINS                              DATE 11/27/95   TIME 10:31              HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                          COMPUTER PROGRAM  HDT 3.4-R             H .132  C .848  O .020  X .000
ENGINE CYCLE   DIESEL                                 CELL  7      BAG CART 1                 ENGINE OIL
ENGINE SERIAL  6B7AA5.9                               REE20                                   CATALYST

BAROMETER 735.1 MM HG (28.94 IN HG)      CVS:  74.0°F  RH 51. PCT  AH  66.0 GR/LB             ENGINE DEW PT. 13.8°C (56.8°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)         ENGINE: RH 45. PCT  AH 10.2 G/KG ( 71.4 GR/LB)       NOX HUMIDITY C.F.  .991
                                         REFERENCE WORK  9.11 KW HR (12.22 HP HR)             DRY-TO-WET C.F.   .979

                            SAMPLE               BACKGROUND
  FORMALDEHYDE
    PPM                        .373                  .005
    MASS  MG                 318.75
  ACETALDEHYDE
    PPM                        .121                  .000
    MASS  MG                 153.36
  ACROLEIN
    PPM                        .018                  .000
    MASS  MG                  28.31
  ACETONE
    PPM                        .028                  .007
    MASS  MG                  35.98
  PROP
    PPM                        .012                  .004
    MASS  MG                  14.80
  CROTONALD.
    PPM                        .008                  .000
    MASS  MG                  16.21
  ISOBUTYR+MEK
    PPM                        .003                  .000
    MASS  MG                   5.77
  BENZALDEHYDE
    PPM                        .003                  .000
    MASS  MG                   7.66
  HEXANALDEHYDE
    PPM                        .000                  .000
    MASS  MG                    .00

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR            26.149          CROTONALD.    MG/HP-HR            1.330
              ACETALDEHYDE MG/HP-HR            12.580          ISOBUTYR+MEK  MG/HP-HR             .473
              ACROLEIN     MG/HP-HR             2.322          BENZALDEHYDE  MG/HP-HR             .628
              ACETONE      MG/HP-HR             2.952          HEXANALDEHYDE MG/HP-HR             .000
              PROPIONALD.  MG/HP-HR             1.214
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                         SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                    EPA  HOT TRANS  ENGINE EMISSION RESULTS              PROJECT NO. 08-7507-001

ENGINE  NUMBER                               TEST  FC-H2            RUN                DIESEL   REE20    EM-2135-F
ENGINE MODEL  95 CUMMINS                     DATE 11/27/95   TIME 11:11                HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                 COMPUTER PROGRAM  HDT 3.4-R               H .132  C .848  O .020  X .000
ENGINE CYCLE   DIESEL                        CELL  7      BAG CART 1                   ENGINE OIL
ENGINE SERIAL  6B7AA5.9                      REE20                                     CATALYST

BAROMETER 734.8 MM HG (28.93 IN HG)    CVS:  73.0°F  RH 50. PCT  AH  63.1 GR/LB        ENGINE DEW PT. 13.2°C (55.8°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)       ENGINE: RH 43. PCT  AH  9.8 G/KG ( 68.8 GR/LB)  NOX HUMIDITY C.F.  .984
                                       REFERENCE WORK  9.11 KW HR (12.22 HP HR)        DRY-TO-WET C.F.    .980
BAG RESULTS
  BAG NUMBER                                  1
  TIME SECONDS                             1207.5
  TOT. BLOWER RATE SCMM (SCFM)           33.59 (1186.0)
  TOT. 90MM RATE SCMM (SCFM)               .06 ( 2.26)
  TOT. 20X20 RATE SCMM (SCFM)             1.48 ( 52.3)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)        .09 ( 3.09)
  TOTAL FLOW STD. CU. METRES(SCF)        708.8 ( 25028.)

  HC  SAMPLE METER/RANGE/PPM               .1/ 76/   9.33
  HC  BCKGRD METER/RANGE/PPM               .1/ 76/   5.22
  CO  SAMPLE METER/RANGE/PPM             14.9/ 12/  14.31
  CO  BCKGRD METER/RANGE/PPM               .6/ 12/    .57
  CO2 SAMPLE METER/RANGE/PCT             76.0/ 11/  .6597
  CO2 BCKGRD METER/RANGE/PCT              8.6/ 11/  .0507
  NOX SAMPLE METER/RANGE/PPM (D)           .5/ 73/  40.48
  NOX BCKGRD METER/RANGE/PPM               .8/  2/    .82

  DILUTION FACTOR                             20.42
  HC  CONCENTRATION PPM                        4.37
  CO  CONCENTRATION PPM                       13.37
  CO2 CONCENTRATION PCT                       .6115
  NOX CONCENTRATION PPM                       38.87

  HC  MASS GRAMS                              1.822
  CO  MASS GRAMS                             11.033
  CO2 MASS GRAMS                            7928.83
  NOX MASS GRAMS                             51.857
  FUEL  KG (LB)                          2.560 (  5.64)
  KW HR (HP HR)                           9.09 ( 12.19)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .200(   .149) (   .15) (CONT)      90 MM FLTR NUMBERS          2590.0-197  P90-
  BSCO   G/KW HR (G/HP HR)      1.214(   .905) (   .91)             90 MM FLTR WT. GAINS (MG)     1.477          .000
  BSNOX  G/KW HR (G/HP HR)      5.705(  4.254) (  4.25) (CONT)      PARTICULATE GRAMS/TEST                .812
  PART.  G/KW HR (G/HP HR)       .089(   .067) (   .07)
  BSFC  KG/KW HR (LB/HP HR)      .282(   .463)
  WORK      KW HR (HP HR)        9.09(  12.19)
  BSCO2  G/KW HR (G/HP HR)      872. (   650.)
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                                   EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                    TEST  F-C1            RUN             DIESEL   REE20    EM-2135-F
ENGINE MODEL  95 CUMMINS                          DATE 11/28/95   TIME 9:09             HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                      COMPUTER PROGRAM  HDT 3.4-R           H .132  C .848  O .020  X .000
ENGINE CYCLE   DIESEL                             CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                           REE20

BAROMETER 744.4 MM HG (29.31 IN HG)       CVS:  69.0°F  RH 22. PCT  AH  23.5 GR/LB         ENGINE DEW PT. 12.6°C (54.6°F)
ENGINE AIR TEMP. 24.4°C (76.0°F)          ENGINE: RH 47. PCT  AH  9.3 G/KG ( 65.0 GR/LB)  NOX HUMIDITY C.F.  .975
                                          REFERENCE WORK  9.05 KW HR (12.13 HP HR)         DRY-TO-WET C.F.   .989
BAG RESULTS
  BAG NUMBER                                      1
  TIME SECONDS                                 1207.1
  TOT. BLOWER RATE SCMM (SCFM)              34.29 (1210.6)
  TOT. 90MM RATE SCMM (SCFM)                  .06 ( 2.26)
  TOT. 20X20 RATE SCMM (SCFM)                1.49 ( 52.4)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)           .09 ( 3.10)
  TOTAL FLOW STD. CU. METRES(SCF)           722.7 ( 25519.)

  HC  SAMPLE METER/RANGE/PPM                  .1/ 76/  11.72
  HC  BCKGRD METER/RANGE/PPM                  .0/ 76/   3.78
  CO  SAMPLE METER/RANGE/PPM                26.1/ 12/  25.31
  CO  BCKGRD METER/RANGE/PPM                  .7/ 12/    .66
  CO2 SAMPLE METER/RANGE/PCT                73.8/ 11/  .6329
  CO2 BCKGRD METER/RANGE/PCT                 7.8/ 11/  .0458
  NOX SAMPLE METER/RANGE/PPM (D)              .5/ 73/  41.55
  NOX BCKGRD METER/RANGE/PPM                  .5/  2/    .51

  DILUTION FACTOR                                 21.24
  HC  CONCENTRATION PPM                            8.12
  CO  CONCENTRATION PPM                           24.20
  CO2 CONCENTRATION PCT                           .5893
  NOX CONCENTRATION PPM                           40.59

  HC  MASS GRAMS                                  3.454
  CO  MASS GRAMS                                 20.360
  CO2 MASS GRAMS                               7790.82
  NOX MASS GRAMS                                 54.680
  FUEL  KG (LB)                             2.522 (  5.56)
  KW HR (HP HR)                              9.16 ( 12.29)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .377(   .281) (   .28) (CONT)      90 MM FLTR NUMBERS          2591.0-198  P90-
  BSCO   G/KW HR (G/HP HR)       2.222(  1.657) (  1.66)             90 MM FLTR WT. GAINS (MG)     2.465         .000
  BSNOX  G/KW HR (G/HP HR)       5.966(  4.449) (  4.45) (CONT)      PARTICULATE GRAMS/TEST               1.383
  PART.  G/KW HR (G/HP HR)        .151(   .112) (   .11)
  BSFC  KG/KW HR (LB/HP HR)       .275(   .452)
  WORK      KW HR (HP HR)         9.16(  12.29)
  BSCO2  G/KW HR (G/HP HR)       850. (   634.)
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                              SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                      EPA  COLD TRANS ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                   TEST  F-C1          RUN           DIESEL   REE20    EM-2135-F
ENGINE MODEL  95 CUMMINS                         DATE 11/28/95   TIME 9:09         HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                     COMPUTER PROGRAM  HDT 3.4-R       H .132  C .848  O .020  X .000
ENGINE CYCLE   DIESEL                            CELL  7      BAG CART 1           ENGINE OIL
ENGINE SERIAL  6B7AA5.9                          REE20

BAROMETER 744.4 MM HG (29.31 IN HG)    CVS:  69.0°F  RH 22. PCT  AH  23.5 GR/LB      ENGINE DEW PT. 12.6°C (54.6°F)
ENGINE AIR TEMP. 24.4°C (76.0°F)       ENGINE: RH 47. PCT  AH  9.3 G/KG ( 65.0 GR/LB) NOX HUMIDITY C.F.  .975
                                       REFERENCE WORK  9.05 KW HR (12.13 HP HR)      DRY-TO-WET C.F.   .989

                          SAMPLE             BACKGROUND
  FORMALDEHYDE
    PPM                    .591                .000
    MASS  MG             527.42
  ACETALDEHYDE
    PPM                    .145                .003
    MASS  MG             187.23
  ACROLEIN
    PPM                    .023                .000
    MASS  MG              37.68
  ACETONE
    PPM                    .028                .006
    MASS  MG              38.30
  PROPIONALDEHYDE
    PPM                    .019                .005
    MASS  MG              24.26
  CROTONALDEHYDE
    PPM                    .017                .000
    MASS  MG              34.40
  ISOBUTYR+MEK
    PPM                    .018                .000
    MASS  MG              38.11
  BENZALDEHYDE
    PPM                    .015                .000
    MASS  MG              46.13
  HEXANALDEHYDE
    PPM                    .027                .000
    MASS  MG              81.00

TOTAL RESULTS
             FORMALDEHYDE MG/HP-HR           42.915         CROTONALD.    MG/HP-HR            2.799
             ACETALDEHYDE MG/HP-HR           15.234         ISOBUTYR+MEK  MG/HP-HR            3.101
             ACROLEIN     MG/HP-HR            3.066         BENZALDEHYDE  MG/HP-HR            3.754
             ACETONE      MG/HP-HR            3.116         HEXANALDEHYDE MG/HP-HR            6.591
             PROPIONALD.  MG/HP-HR            1.974
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                                      EPA  HOT TRANS  ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                  TEST  F-H1            RUN               DIESEL   REE20    EM-2135-F
ENGINE MODEL  95 CUMMINS                        DATE 11/28/95   TIME 9:49               HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                    COMPUTER PROGRAM  HDT 3.4-R             H .132  C .848  O .020  X .000
ENGINE CYCLE   DIESEL                           CELL  7      BAG CART 1                 ENGINE OIL
ENGINE SERIAL  6B7AA5.9                         REE20

BAROMETER 744.8 MM HG (29.32 IN HG)     CVS:  69.0°F  RH 22. PCT  AH  23.5 GR/LB        ENGINE DEW PT. 12.8°C (55.1°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)        ENGINE: RH 44. PCT  AH  9.5 G/KG ( 66.2 GR/LB)  NOX HUMIDITY C.F.  .978
                                        REFERENCE WORK  9.05 KW HR (12.13 HP HR)        DRY-TO-WET C.F.   .989
BAG RESULTS
  BAG NUMBER                                        1
  TIME SECONDS                                   1207.9
  TOT. BLOWER RATE SCMM (SCFM)                34.35 (1212.8)
  TOT. 90MM RATE SCMM (SCFM)                    .06 ( 2.27)
  TOT. 20X20 RATE SCMM (SCFM)                  1.49 ( 52.5)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)             .09 ( 3.09)
  TOTAL FLOW STD. CU. METRES(SCF)             724.4 ( 25580.)

  HC  SAMPLE METER/RANGE/PPM                    .1/ 76/   9.92
  HC  BCKGRD METER/RANGE/PPM                    .0/ 76/   3.75
  CO  SAMPLE METER/RANGE/PPM                  18.0/ 12/  17.34
  CO  BCKGRD METER/RANGE/PPM                    .1/ 12/    .09
  CO2 SAMPLE METER/RANGE/PCT                  72.2/ 11/  .6137
  CO2 BCKGRD METER/RANGE/PCT                   7.7/ 11/  .0452
  NOX SAMPLE METER/RANGE/PPM (D)                .5/ 73/  39.44
  NOX BCKGRD METER/RANGE/PPM                    .5/  2/    .51

  DILUTION FACTOR                                  21.93
  HC  CONCENTRATION PPM                             6.34
  CO  CONCENTRATION PPM                            16.93
  CO2 CONCENTRATION PCT                            .5706
  NOX CONCENTRATION PPM                            38.51

  HC  MASS GRAMS                                   2.704
  CO  MASS GRAMS                                  14.275
  CO2 MASS GRAMS                                 7562.58
  NOX MASS GRAMS                                  52.158
  FUEL  KG (LB)                               2.445 (  5.39)
  KW HR (HP HR)                                9.10 ( 12.21)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .297(   .221) (   .22) (CONT)      90 MM FLTR NUMBERS           2601.0-209  P90-
  BSCO   G/KW HR (G/HP HR)       1.568(  1.169) (  1.17)             90 MM FLTR WT. GAINS (MG)      2.111          .000
  BSNOX  G/KW HR (G/HP HR)       5.729(  4.272) (  4.27) (CONT)      PARTICULATE GRAMS/TEST              1.182
  PART.  G/KW HR (G/HP HR)        .130(   .097) (   .10)
  BSFC  KG/KW HR (LB/HP HR)       .268(   .441)
  WORK      KW HR (HP HR)         9.10(  12.21)
  BSCO2  G/KW HR (G/HP HR)       831. (   619.)
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                         SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                  EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                              TEST  F-H1          RUN              DIESEL   REE20    EM-2135-F
ENGINE MODEL  95 CUMMINS                    DATE 11/28/95   TIME 9:49            HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                COMPUTER PROGRAM  HDT 3.4-R          H .132  C .848  O .020  X .000
ENGINE CYCLE   DIESEL                       CELL  7      BAG CART 1              ENGINE OIL
ENGINE SERIAL  6B7AA5.9                     REE20

BAROMETER 744.8 MM HG (29.32 IN HG)    CVS:  69.0°F  RH 22. PCT  AH  23.5 GR/LB          ENGINE DEW PT. 12.8°C (55.1°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)       ENGINE: RH 44. PCT  AH  9.5 G/KG ( 66.2 GR/LB)   NOX HUMIDITY C.F.  .978
                                       REFERENCE WORK  9.05 KW HR (12.13 HP HR)          DRY-TO-WET C.F.   .989

                      SAMPLE             BACKGROUND
 FORMALDEHYDE
   PPM                 1.163                .000
   MASS  MG           1040.51
 ACETALDEHYDE
   PPM                  .093                .003
   MASS  MG            119.31
 ACROLEIN
   PPM                  .015                .000
   MASS  MG             24.66
 ACETONE
   PPM                  .024                .006
   MASS  MG             30.11
 PROP
   PPM                  .022                .005
   MASS  MG             30.12
 CROTONALD.
   PPM                  .010                .000
   MASS  MG             19.95
 ISOBUTYR+MEK
   PPM                  .004                .000
   MASS  MG              8.76
 BENZALDEHYDE
   PPM                  .009                .000
   MASS  MG             28.83
 HEXANALDEHYDE
   PPM                  .021                .000
   MASS  MG             63.54

TOTAL RESULTS
           FORMALDEHYDE MG/HP-HR          85.218        CROTONALD.    MG/HP-HR            1.634
           ACETALDEHYDE MG/HP-HR           9.771        ISOBUTYR+MEK  MG/HP-HR             .718
           ACROLEIN     MG/HP-HR           2.020        BENZALDEHYDE  MG/HP-HR            2.361
           ACETONE      MG/HP-HR           2.466        HEXANALDEHYDE MG/HP-HR            5.204
           PROPIONALD.  MG/HP-HR           2.467
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                                  EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                   TEST  F-H2            RUN               DIESEL   REE20    EM-2135-F
ENGINE MODEL  95 CUMMINS                         DATE 11/28/95   TIME 10:29              HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                     COMPUTER PROGRAM  HDT 3.3-R             H .132  C .848  O .020  X .000
ENGINE CYCLE   DIESEL                            CELL  7      BAG CART 1                 ENGINE OIL
ENGINE SERIAL  6B7AA5.9                          REE20

BAROMETER 744.9 MM HG (29.33 IN HG)        CVS:  70.0°F  RH 20.0 PCT  AH  21.8 GR/LB     ENGINE DEW PT. 12.7°C (54.8°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)           ENGINE ABS. HUM.  9.3 G/KG ( 65.4 GR/LB)      NOX HUMIDITY C.F.  .976
                                                                                         DRY-TO-WET C.F.   .989
BAG RESULTS
  BAG NUMBER                                     1
  TIME SECONDS                                 1207.4
  TOT. BLOWER RATE SCMM (SCFM)              34.29 (1210.7)
  TOT. 90MM RATE SCMM (SCFM)                  .06 ( 2.27)
  TOT. 20X20 RATE SCMM (SCFM)                1.47 ( 52.0)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)           .09 ( 3.10)
  TOTAL FLOW STD. CU. METRES(SCF)           722.7 ( 25518.)

  HC  SAMPLE METER/RANGE/PPM                  .1/ 76/  10.02
  HC  BCKGRD METER/RANGE/PPM                  .0/ 76/   3.92
  CO  SAMPLE METER/RANGE/PPM                18.0/ 12/  17.34
  CO  BCKGRD METER/RANGE/PPM                  .1/ 12/    .09
  CO2 SAMPLE METER/RANGE/PCT                72.5/ 11/  .6173
  CO2 BCKGRD METER/RANGE/PCT                 7.8/ 11/  .0458
  NOX SAMPLE METER/RANGE/PPM (D)              .5/ 73/  39.49
  NOX BCKGRD METER/RANGE/PPM                  .3/  2/    .31

  DILUTION FACTOR                                21.80
  HC  CONCENTRATION PPM                           6.28
  CO  CONCENTRATION PPM                          16.94
  CO2 CONCENTRATION PCT                          .5736
  NOX CONCENTRATION PPM                          38.77

  HC  MASS GRAMS                                 2.671
  CO  MASS GRAMS                                14.250
  CO2 MASS GRAMS                               7583.68
  NOX MASS GRAMS                                52.283
  FUEL  KG (LB)                             2.451 (  5.40)
  KW HR (HP HR)                              9.07 ( 12.16)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)      .295(  .220) (  .22) (CONT)      90 MM FILTER NUMBERS         2602.0-  P90-
  BSCO   G/KW HR (G/HP HR)     1.571( 1.172) ( 1.17)             90 MM FILTER WT. GAINS (MG)   2.132    .000
  BSNOX  G/KW HR (G/HP HR)     5.766( 4.300) ( 4.30) (CONT)      PARTICULATE GRAMS/TEST            1.190
  PART.  G/KW HR (G/HP HR)      .131(  .098) (  .10)
  BSFC  KG/KW HR (LB/HP HR)     .270(   .444)
  WORK      KW HR (HP HR)       9.07(  12.16)
  BSCO2  G/KW HR (G/HP HR)      836. (   624.)
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                         SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                 EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                           TEST  G-C1            RUN              DIESEL   RME20    EM-2137-F
ENGINE MODEL  95 CUMMINS                 DATE 11/29/95   TIME 10:44             HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6             COMPUTER PROGRAM  HDT 3.4-R            H .131  C .842  O .027  X .000
ENGINE CYCLE   DIESEL                    CELL  7      BAG CART 1                ENGINE OIL
ENGINE SERIAL  6B7AA5.9                  RME20

BAROMETER 745.7 MM HG (29.36 IN HG)    CVS:  76.0°F  RH 23. PCT  AH  31.1 GR/LB      ENGINE DEW PT. 13.3°C (56.0°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)       ENGINE: RH 44. PCT  AH  9.8 G/KG ( 68.3 GR/LB) NOX HUMIDITY C.F.  .983
                                       REFERENCE WORK  9.07 KW HR (12.16 HP HR)       DRY-TO-WET C.F.   .987
BAG RESULTS
  BAG NUMBER                                   1
  TIME SECONDS                              1207.3
  TOT. BLOWER RATE SCMM (SCFM)           33.95 (1198.6)
  TOT. 90MM RATE SCMM (SCFM)               .06 ( 2.26)
  TOT. 20X20 RATE SCMM (SCFM)             1.51 ( 53.3)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)        .09 ( 3.09)
  TOTAL FLOW STD. CU. METRES(SCF)        716.5 ( 25298.)

  HC  SAMPLE METER/RANGE/PPM               .1/ 76/  11.66
  HC  BCKGRD METER/RANGE/PPM               .1/ 76/   4.68
  CO  SAMPLE METER/RANGE/PPM             24.7/ 12/  23.93
  CO  BCKGRD METER/RANGE/PPM              2.8/ 12/   2.65
  CO2 SAMPLE METER/RANGE/PCT             73.8/ 11/  .6329
  CO2 BCKGRD METER/RANGE/PCT              8.4/ 11/  .0495
  NOX SAMPLE METER/RANGE/PPM (D)           .5/ 73/  42.38
  NOX BCKGRD METER/RANGE/PPM               .2/  2/    .21

  DILUTION FACTOR                              21.28
  HC  CONCENTRATION PPM                         7.20
  CO  CONCENTRATION PPM                        20.95
  CO2 CONCENTRATION PCT                        .5857
  NOX CONCENTRATION PPM                        41.63

  HC  MASS GRAMS                                3.058
  CO  MASS GRAMS                               17.477
  CO2 MASS GRAMS                             7676.99
  NOX MASS GRAMS                               56.072
  FUEL  KG (LB)                          2.501 (  5.51)
  KW HR (HP HR)                           9.14 ( 12.26)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .335(   .249) (   .25) (CONT)     90 MM FLTR NUMBERS          2604.0-233  P90-
  BSCO   G/KW HR (G/HP HR)      1.912(  1.426) (  1.43)            90 MM FLTR WT. GAINS (MG)     2.230          .000
  BSNOX  G/KW HR (G/HP HR)      6.133(  4.574) (  4.57) (CONT)     PARTICULATE GRAMS/TEST               1.240
  PART.  G/KW HR (G/HP HR)       .136(   .101) (   .10)
  BSFC  KG/KW HR (LB/HP HR)      .274(   .450)
  WORK     KW HR (HP HR)         9.14(  12.26)
  BSCO2  G/KW HR (G/HP HR)      840. (   626.)
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                                             EPA  COLD TRANS ENGINE EMISSION RESULTS           PROJECT NO. 08-7507-001

ENGINE  NUMBER                                       TEST  G-C1            RUN                DIESEL   RME20    EM-2137-F
ENGINE MODEL  95 CUMMINS                             DATE 11/29/95   TIME 10:44               HCR 1.85  FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6                        COMPUTER PROGRAM  HDT 3.4-R              H .131  C .842  O .027  X .000
ENGINE CYCLE   DIESEL                                CELL  7      BAG CART 1                  ENGINE OIL
ENGINE SERIAL  6B7AA5.9                              RME20

BAROMETER 745.7 MM HG (29.36 IN HG)        CVS:  76.0°F  RH 23. PCT  AH  31.1 GR/LB           ENGINE DEW PT. 13.3°C (56.0°F)
ENGINE AIR TEMP. 26.7°C (80.0°F)           ENGINE: RH 44. PCT  AH  9.8 G/KG ( 68.3 GR/LB)   NOX HUMIDITY C.F.  .983
                                           REFERENCE WORK  9.07 KW HR (12.16 HP HR)           DRY-TO-WET C.F.   .987

                           SAMPLE                BACKGROUND
  FORMALDEHYDE
    PPM                     .474                   .001
    MASS  MG              417.76
  ACETALDEHYDE
    PPM                     .117                   .005
    MASS  MG              145.42
  ACROLEIN
    PPM                     .036                   .000
    MASS  MG               58.64
  ACETONE
    PPM                     .025                   .005
    MASS  MG               33.84
  PROPIONALDEHYDE
    PPM                     .020                   .000
    MASS  MG               34.37
  CROTONALDEHYDE
    PPM                     .013                   .000
    MASS  MG               26.97
  ISOBUTYR+MEK
    PPM                     .020                   .000
    MASS  MG               42.35
  BENZALDEHYDE
    PPM                     .006                   .000
    MASS  MG               19.25
  HEXANALDEHYDE
    PPM                     .012                   .000
    MASS  MG               36.71

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR              34.075          CROTONALD.     MG/HP-HR             2.200
              ACETALDEHYDE MG/HP-HR              11.861          ISOBUTYR+MEK   MG/HP-HR             3.454
              ACROLEIN     MG/HP-HR               4.783          BENZALDEHYDE   MG/HP-HR             1.570
              ACETONE      MG/HP-HR               2.760          HEXANALDEHYDE  MG/HP-HR             2.995
              PROPIONALD.  MG/HP-HR               2.803
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                                        EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                              TEST  G-H1           RUN            DIESEL   RME20    EM-2137-F
ENGINE MODEL  95 CUMMINS                    DATE 11/29/95   TIME 11:24          HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                COMPUTER PROGRAM  HDT 3.4-R         H .131  C .842  O .027  X .000
ENGINE CYCLE   DIESEL                       CELL  7      BAG CART 1             ENGINE OIL
ENGINE SERIAL  6B7AA5.9                     RME20

BAROMETER 745.6 MM HG (29.35 IN HG)    CVS:  75.0°F  RH 25. PCT  AH  32.7 GR/LB          ENGINE DEW PT. 13.4°C (56.1°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)       ENGINE: RH 43. PCT  AH  9.8 G/KG ( 68.6 GR/LB)  NOX HUMIDITY C.F.  .984
                                       REFERENCE WORK  9.07 KW HR (12.16 HP HR)         DRY-TO-WET C.F.   .987

BAG RESULTS
  BAG NUMBER                                  1
  TIME SECONDS                             1207.2
  TOT. BLOWER RATE SCMM (SCFM)           33.79 (1193.3)
  TOT. 90MM RATE SCMM (SCFM)               .07 ( 2.31)
  TOT. 20X20 RATE SCMM (SCFM)             1.51 ( 53.5)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)        .10 ( 3.36)
  TOTAL FLOW STD. CU. METRES(SCF)        713.6 ( 25198.)

  HC  SAMPLE METER/RANGE/PPM               .1/ 76/  10.25
  HC  BCKGRD METER/RANGE/PPM               .1/ 76/   4.48
  CO  SAMPLE METER/RANGE/PPM             18.1/ 12/  17.44
  CO  BCKGRD METER/RANGE/PPM              1.5/ 12/   1.42
  CO2 SAMPLE METER/RANGE/PCT             72.4/ 11/  .6161
  CO2 BCKGRD METER/RANGE/PCT              8.2/ 11/  .0483
  NOX SAMPLE METER/RANGE/PPM (D)           .5/ 73/  40.48
  NOX BCKGRD METER/RANGE/PPM               .3/  2/    .31

  DILUTION FACTOR                             21.88
  HC  CONCENTRATION PPM                        5.97
  CO  CONCENTRATION PPM                       15.75
  CO2 CONCENTRATION PCT                       .5701
  NOX CONCENTRATION PPM                       39.65

  HC  MASS GRAMS                               2.528
  CO  MASS GRAMS                              13.087
  CO2 MASS GRAMS                            7442.33
  NOX MASS GRAMS                              53.225
  FUEL  KG (LB)                          2.422 (  5.34)
  KW HR (HP HR)                           9.08 ( 12.18)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .278(   .208) (   .21) (CONT)     90 MM FLTR NUMBERS          2605.0-234  P90-
  BSCO   G/KW HR (G/HP HR)      1.441(  1.074) (  1.07)            90 MM FLTR WT. GAINS (MG)     2.008          .000
  BSNOX  G/KW HR (G/HP HR)      5.860(  4.370) (  4.37) (CONT)     PARTICULATE GRAMS/TEST                1.089
  PART.  G/KW HR (G/HP HR)       .120(   .089) (   .09)
  BSFC  KG/KW HR (LB/HP HR)      .267(   .438)
  WORK      KW HR (HP HR)        9.08(  12.18)
  BSCO2  G/KW HR (G/HP HR)      819. (   611.)
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                                         EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                  TEST  G-H1           RUN                 DIESEL   RME20    EM-2137-F
ENGINE MODEL  95 CUMMINS                        DATE 11/29/95   TIME 11:24               HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                    COMPUTER PROGRAM  HDT 3.4-R              H .131  C .842  O .027  X .000
ENGINE CYCLE   DIESEL                           CELL  7      BAG CART 1                  ENGINE OIL
ENGINE SERIAL  6B7AA5.9                         RME20

BAROMETER 745.6 MM HG (29.35 IN HG)     CVS:  75.0°F  RH 25. PCT  AH  32.7 GR/LB         ENGINE DEW PT. 13.4°C (56.1°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)        ENGINE: RH 43. PCT  AH  9.8 G/KG ( 68.6 GR/LB)  NOX HUMIDITY C.F.  .984
                                        REFERENCE WORK  9.07 KW HR (12.16 HP HR)         DRY-TO-WET C.F.   .987

                           SAMPLE                BACKGROUND
  FORMALDEHYDE
    PPM                      .304                   .001
    MASS  MG               266.17
  ACETALDEHYDE
    PPM                      .081                   .005
    MASS  MG                98.62
  ACROLEIN
    PPM                      .010                   .000
    MASS  MG                17.20
  ACETONE
    PPM                      .012                   .005
    MASS  MG                11.53
  PROP
    PPM                      .017                   .000
    MASS  MG                28.08
  CROTONALD.
    PPM                      .007                   .000
    MASS  MG                14.05
  ISOBUTYR+MEK
    PPM                      .014                   .000
    MASS  MG                28.77
  BENZALDEHYDE
    PPM                      .004                   .000
    MASS  MG                12.71
  HEXANALDEHYDE
    PPM                      .008                   .000
    MASS  MG                23.25

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR           21.853         CROTONALD.    MG/HP-HR           1.154
              ACETALDEHYDE MG/HP-HR            8.097         ISOBUTYR+MEK  MG/HP-HR           2.362
              ACROLEIN     MG/HP-HR            1.412         BENZALDEHYDE  MG/HP-HR           1.043
              ACETONE      MG/HP-HR             .947         HEXANALDEHYDE MG/HP-HR           1.909
              PROPIONALD.  MG/HP-HR            2.305
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                                  EPA  HOT TRANS  ENGINE EMISSION RESULTS            PROJECT NO. 08-7507-001

ENGINE  NUMBER                            TEST  G-H2           RUN            DIESEL   RME20    EM-2137-F
ENGINE MODEL  95 CUMMINS                  DATE 11/29/95   TIME 12:04          HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6              COMPUTER PROGRAM  HDT 3.3-R         H .131  C .842  O .027  X .000
ENGINE CYCLE   DIESEL                     CELL  7      BAG CART 1             ENGINE OIL
ENGINE SERIAL  6B7AA5.9                   RME20

BAROMETER 745.1 MM HG (29.33 IN HG)     CVS:  75.0°F  RH 25.0 PCT  AH  32.8 GR/LB     ENGINE DEW PT. 13.2°C (55.8°F)
ENGINE AIR TEMP. 27.8°C (82.0°F)        ENGINE ABS. HUM.  9.7 G/KG ( 67.9 GR/LB)      NOX HUMIDITY C.F.  .982
                                                                                      DRY-TO-WET C.F.   .987
BAG RESULTS
  BAG NUMBER                                   1
  TIME SECONDS                              1207.2
  TOT. BLOWER RATE SCMM (SCFM)            34.01 (1200.9)
  TOT. 90MM RATE SCMM (SCFM)                .06 (  2.27)
  TOT. 20X20 RATE SCMM (SCFM)              1.53 (  54.0)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)         .09 (  3.13)
  TOTAL FLOW STD. CU. METRES(SCF)         718.1 ( 25357.)

  HC  SAMPLE METER/RANGE/PPM               .1/ 76/  11.04
  HC  BCKGRD METER/RANGE/PPM               .1/ 76/   5.27
  CO  SAMPLE METER/RANGE/PPM             18.2/ 12/  17.54
  CO  BCKGRD METER/RANGE/PPM              1.2/ 12/   1.13
  CO2 SAMPLE METER/RANGE/PCT             72.9/ 11/  .6221
  CO2 BCKGRD METER/RANGE/PCT              8.2/ 11/  .0483
  NOX SAMPLE METER/RANGE/PPM (D)           .5/ 73/  40.26
  NOX BCKGRD METER/RANGE/PPM               .5/  2/    .51

  DILUTION FACTOR                             21.67
  HC  CONCENTRATION PPM                        6.01
  CO  CONCENTRATION PPM                       16.12
  CO2 CONCENTRATION PCT                       .5761
  NOX CONCENTRATION PPM                       39.24

  HC  MASS GRAMS                               2.560
  CO  MASS GRAMS                              13.473
  CO2 MASS GRAMS                            7567.84
  NOX MASS GRAMS                              52.903
  FUEL  KG (LB)                           2.463 (  5.43)
  KW HR (HP HR)                            9.06 ( 12.15)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)     .283(  .211) (  .21) (CONT)      90 MM FILTER NUMBERS          2606.0-  P90-
  BSCO   G/KW HR (G/HP HR)    1.487( 1.109) ( 1.11)             90 MM FILTER WT. GAINS (MG)   2.079     .000
  BSNOX  G/KW HR (G/HP HR)    5.839( 4.354) ( 4.35) (CONT)      PARTICULATE GRAMS/TEST           1.154
  PART.  G/KW HR (G/HP HR)     .127(  .095) (  .09)
  BSFC  KG/KW HR (LB/HP HR)     .272(   .447)
  WORK      KW HR (HP HR)      9.06(  12.15)
  BSCO2  G/KW HR (G/HP HR)    835. (   623.)
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                  SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                           EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                               TEST  GC-C1          RUN              DIESEL   RME20    EM-2137-F
ENGINE MODEL  95 CUMMINS                     DATE 11/30/95   TIME                  HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                 COMPUTER PROGRAM  HDT 3.4-R           H .131  C .842  O .027  X .000
ENGINE CYCLE   DIESEL                        CELL  7      BAG CART 1               ENGINE OIL
ENGINE SERIAL  6B7AA5.9                      RME20                                 CATALYST

BAROMETER 742.2 MM HG (29.22 IN HG)      CVS:  73.0°F  RH 33. PCT  AH  40.4 GR/LB        ENGINE DEW PT. 13.3°C (56.0°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)         ENGINE: RH 45. PCT  AH  9.8 G/KG ( 68.6 GR/LB)  NOX HUMIDITY C.F.  .984
                                         REFERENCE WORK  9.08 KW HR (12.17 HP HR)        DRY-TO-WET C.F.   .985
BAG RESULTS
  BAG NUMBER                                    1
  TIME SECONDS                               1207.4
  TOT. BLOWER RATE SCMM (SCFM)            33.49 (1182.5)
  TOT. 90MM RATE SCMM (SCFM)                .07 ( 2.30)
  TOT. 20X20 RATE SCMM (SCFM)              1.49 ( 52.6)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)         .09 ( 3.11)
  TOTAL FLOW STD. CU. METRES(SCF)         707.0 ( 24965.)

  HC  SAMPLE METER/RANGE/PPM                .1/ 76/  10.59
  HC  BCKGRD METER/RANGE/PPM                .1/ 76/   5.52
  CO  SAMPLE METER/RANGE/PPM              21.9/ 12/  21.17
  CO  BCKGRD METER/RANGE/PPM               1.6/ 12/   1.51
  CO2 SAMPLE METER/RANGE/PCT              74.9/ 11/  .6462
  CO2 BCKGRD METER/RANGE/PCT               8.9/ 11/  .0526
  NOX SAMPLE METER/RANGE/PPM (D)            .5/ 73/  42.41
  NOX BCKGRD METER/RANGE/PPM                .6/  2/    .62

  DILUTION FACTOR                               20.85
  HC  CONCENTRATION PPM                          5.33
  CO  CONCENTRATION PPM                         19.26
  CO2 CONCENTRATION PCT                         .5961
  NOX CONCENTRATION PPM                         41.18

  HC  MASS GRAMS                                2.236
  CO  MASS GRAMS                               15.853
  CO2 MASS GRAMS                              7710.54
  NOX MASS GRAMS                               54.770
  FUEL  KG (LB)                           2.510 (  5.53)
  KW HR (HP HR)                            9.18 ( 12.31)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)       .244(   .182) (   .18) (CONT)      90 MM FLTR NUMBERS          2964.0-243  P90-
  BSCO   G/KW HR (G/HP HR)      1.727(  1.288) (  1.29)             90 MM FLTR WT. GAINS (MG)     1.657          .000
  BSNOX  G/KW HR (G/HP HR)      5.967(  4.449) (  4.45) (CONT)      PARTICULATE GRAMS/TEST                 .893
  PART.  G/KW HR (G/HP HR)       .097(   .073) (   .07)
  BSFC  KG/KW HR (LB/HP HR)      .273(   .450)
  WORK     KW HR (HP HR)         9.18(  12.31)
  BSCO2  G/KW HR (G/HP HR)      840. (   626.)
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                                             EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                              TEST  GC-H1          RUN              DIESEL   RME20    EM-2137-F
ENGINE MODEL  95 CUMMINS                    DATE 11/30/95   TIME 14:12            HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                COMPUTER PROGRAM  HDT 3.4-R           H .131  C .842  O .027  X .000
ENGINE CYCLE   DIESEL                       CELL  7       BAG CART 1              ENGINE OIL
ENGINE SERIAL  6B7AA5.9                     RME20                                 CATALYST

BAROMETER 741.7 MM HG (29.20 IN HG)     CVS:  73.0°F  RH 33. PCT  AH  40.4 GR/LB      ENGINE DEW PT. 13.4°C (56.1°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)        ENGINE: RH 43. PCT  AH  9.8 G/KG ( 68.9 GR/LB) NOX HUMIDITY C.F.  .985
                                        REFERENCE WORK  9.08 KW HR (12.18 HP HR)      DRY-TO-WET C.F.    .985

                         SAMPLE              BACKGROUND
 FORMALDEHYDE
   PPM                    .367                 .003
   MASS  MG             316.41
 ACETALDEHYDE
   PPM                    .123                 .005
   MASS  MG             151.11
 ACROLEIN
   PPM                    .011                 .000
   MASS  MG              17.52
 ACETONE
   PPM                    .024                 .003
   MASS  MG              35.73
 PROP
   PPM                    .013                 .000
   MASS  MG              22.70
 CROTONALD.
   PPM                    .000                 .000
   MASS  MG                .00
 ISOBUTYR+MEK
   PPM                    .007                 .000
   MASS  MG              15.42
 BENZALDEHYDE
   PPM                    .000                 .000
   MASS  MG                .00
 HEXANALDEHYDE
   PPM                    .000                 .000
   MASS  MG                .00

TOTAL RESULTS
           FORMALDEHYDE MG/HP-HR          25.850        CROTONALD.    MG/HP-HR           .000
           ACETALDEHYDE MG/HP-HR          12.345        ISOBUTYR+MEK  MG/HP-HR          1.260
           ACROLEIN     MG/HP-HR           1.431        BENZALDEHYDE  MG/HP-HR           .000
           ACETONE      MG/HP-HR           2.919        HEXANALDEHYDE MG/HP-HR           .000
           PROPIONALD.  MG/HP-HR           1.854
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                                  EPA  COLD TRANS ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                TEST  GC-C1          RUN             DIESEL   RME20    EM-2137-F
ENGINE MODEL  95 CUMMINS                      DATE 11/30/95   TIME                 HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                  COMPUTER PROGRAM  HDT 3.4-R          H .131  C .842  O .027  X .000
ENGINE CYCLE   DIESEL                         CELL  7      BAG CART 1              ENGINE OIL
ENGINE SERIAL  6B7AA5.9                       RME20                                CATALYST

BAROMETER 742.2 MM HG (29.22 IN HG)    CVS:  73.0°F  RH 33. PCT  AH  40.4 GR/LB        ENGINE DEW PT. 13.3°C (56.0°F)
ENGINE AIR TEMP. 26.1°C (79.0°F)       ENGINE: RH 45. PCT  AH  9.8 G/KG ( 68.6 GR/LB)  NOX HUMIDITY C.F.  .984
                                       REFERENCE WORK  9.08 KW HR (12.17 HP HR)        DRY-TO-WET C.F.   .985

                          SAMPLE              BACKGROUND
  FORMALDEHYDE
    PPM                     .593                .003
    MASS  MG              513.77
  ACETALDEHYDE
    PPM                     .187                .005
    MASS  MG              231.65
  ACROLEIN
    PPM                     .037                .000
    MASS  MG               60.43
  ACETONE
    PPM                     .042                .003
    MASS  MG               65.47
  PROPIONALDEHYDE
    PPM                     .028                .000
    MASS  MG               46.33
  CROTONALDEHYDE
    PPM                     .002                .000
    MASS  MG                4.39
  ISOBUTYR+MEK
    PPM                     .017                .000
    MASS  MG               35.24
  BENZALDEHYDE
    PPM                     .007                .000
    MASS  MG               21.26
  HEXANALDEHYDE
    PPM                     .000                .000
    MASS  MG                 .00

TOTAL RESULTS
              FORMALDEHYDE MG/HP-HR          41.736          CROTONALD.    MG/HP-HR              .357
              ACETALDEHYDE MG/HP-HR          18.818          ISOBUTYR+MEK  MG/HP-HR             2.863
              ACROLEIN     MG/HP-HR           4.909          BENZALDEHYDE  MG/HP-HR             1.727
              ACETONE      MG/HP-HR           5.318          HEXANALDEHYDE MG/HP-HR              .000
              PROPIONALD.  MG/HP-HR           3.764
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                     SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                              EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                             TEST  GC-H1          RUN            DIESEL   RME20    EM-2137-F
ENGINE MODEL  95 CUMMINS                   DATE 11/30/95   TIME 14:12          HCR 1.85   FID RES. FAC. 1.000
ENGINE    5.9 L(359. CID) I-6              COMPUTER PROGRAM  HDT 3.4-R         H .131   C .842   O .027   X .000
ENGINE CYCLE   DIESEL                      CELL  7       BAG CART 1            ENGINE OIL
ENGINE SERIAL  6B7AA5.9                    RME20                               CATALYST

BAROMETER 741.7 MM HG (29.20 IN HG)     CVS:  73.0°F  RH 33. PCT  AH  40.4 GR/LB         ENGINE DEW PT. 13.4°C (56.1°F)
ENGINE AIR TEMP. 27.2°C (81.0°F)        ENGINE: RH 43. PCT  AH  9.8 G/KG ( 68.9 GR/LB)   NOX HUMIDITY C.F.  .985
                                        REFERENCE WORK  9.08 KW HR (12.18 HP HR)         DRY-TO-WET C.F.   .985
BAG RESULTS
  BAG NUMBER                                   1
  TIME SECONDS                              1207.7
  TOT. BLOWER RATE SCMM (SCFM)            33.45 (1181.2)
  TOT. 90MM RATE SCMM (SCFM)                .06 ( 2.28)
  TOT. 20X20 RATE SCMM (SCFM)              1.50 ( 52.9)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)         .09 ( 3.15)
  TOTAL FLOW STD. CU. METRES(SCF)         706.6 ( 24951.)

  HC  SAMPLE METER/RANGE/PPM                .1/ 76/   9.32
  HC  BCKGRD METER/RANGE/PPM                .1/ 76/   5.50
  CO  SAMPLE METER/RANGE/PPM              15.6/ 12/  15.00
  CO  BCKGRD METER/RANGE/PPM               1.6/ 12/   1.51
  CO2 SAMPLE METER/RANGE/PCT              73.6/ 11/  .6305
  CO2 BCKGRD METER/RANGE/PCT               8.9/ 11/  .0526
  NOX SAMPLE METER/RANGE/PPM (D)            .5/ 73/  41.18
  NOX BCKGRD METER/RANGE/PPM                .6/  2/    .62

  DILUTION FACTOR                               21.40
  HC  CONCENTRATION PPM                          4.08
  CO  CONCENTRATION PPM                         13.23
  CO2 CONCENTRATION PCT                         .5803
  NOX CONCENTRATION PPM                         39.97

  HC  MASS GRAMS                                1.708
  CO  MASS GRAMS                               10.884
  CO2 MASS GRAMS                              7501.99
  NOX MASS GRAMS                               53.177
  FUEL  KG (LB)                           2.440 (  5.38)
  KW HR (HP HR)                            9.13 ( 12.24)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .187(   .140) (   .14) (CONT)     90 MM FLTR NUMBERS          2965.0-244  P90-
  BSCO   G/KW HR (G/HP HR)       1.192(   .889) (   .89)            90 MM FLTR WT. GAINS (MG)     1.385          .000
  BSNOX  G/KW HR (G/HP HR)       5.826(  4.345) (  4.34) (CONT)     PARTICULATE GRAMS/TEST                 .753
  PART.  G/KW HR (G/HP HR)        .083(   .062) (   .06)
  BSFC  KG/KW HR (LB/HP HR)       .267(   .439)
  WORK      KW HR (HP HR)         9.13(  12.24)
  BSCO2  G/KW HR (G/HP HR)       822. (   613.)
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                         SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH
                                   EPA  HOT TRANS  ENGINE EMISSION RESULTS          PROJECT NO. 08-7507-001

ENGINE  NUMBER                                   TEST  GC-H2          RUN            DIESEL   RME20    EM-2137-F
ENGINE MODEL  95 CUMMINS                         DATE 11/30/95   TIME 14:52          HCR 1.85  FID RES. FAC. 1.000
ENGINE   5.9 L(359. CID) I-6                     COMPUTER PROGRAM  HDT 3.4-R         H .131  C .842  O .027  X .000
ENGINE CYCLE   DIESEL                            CELL  7      BAG CART 1             ENGINE OIL
ENGINE SERIAL  6B7AA5.9                          RME20                               CATALYST

BAROMETER 741.4 MM HG (29.19 IN HG)      CVS:  73.0°F  RH 36. PCT  AH  44.7 GR/LB        ENGINE DEW PT. 13.3°C (56.0°F)
ENGINE AIR TEMP. 27.8°C (82.0°F)         ENGINE: RH 41. PCT  AH  9.8 G/KG ( 68.7 GR/LB)  NOX HUMIDITY C.F.  .984
                                         REFERENCE WORK  9.08 KW HR (12.17 HP HR)        DRY-TO-WET C.F.   .984
BAG RESULTS
  BAG NUMBER                                     1
  TIME SECONDS                                1206.6
  TOT. BLOWER RATE SCMM (SCFM)             33.55 (1184.7)
  TOT. 90MM RATE SCMM (SCFM)                 .06 ( 2.29)
  TOT. 20X20 RATE SCMM (SCFM)               1.53 ( 54.0)
  TOT. AUX. SAMPLE RATE SCMM (SCFM)          .09 ( 3.10)
  TOTAL FLOW STD. CU. METRES(SCF)          708.6 ( 25019.)

  HC  SAMPLE METER/RANGE/PPM                .1/ 76/   9.48
  HC  BCKGRD METER/RANGE/PPM                .1/ 76/   5.43
  CO  SAMPLE METER/RANGE/PPM              16.5/ 12/  15.88
  CO  BCKGRD METER/RANGE/PPM               1.8/ 12/   1.70
  CO2 SAMPLE METER/RANGE/PCT              73.5/ 11/  .6293
  CO2 BCKGRD METER/RANGE/PCT               9.0/ 11/  .0532
  NOX SAMPLE METER/RANGE/PPM (D)            .5/ 73/  40.81
  NOX BCKGRD METER/RANGE/PPM               1.1/  2/   1.13

  DILUTION FACTOR                                21.44
  HC  CONCENTRATION PPM                           4.30
  CO  CONCENTRATION PPM                          13.90
  CO2 CONCENTRATION PCT                          .5785
  NOX CONCENTRATION PPM                          39.08

  HC  MASS GRAMS                                 1.808
  CO  MASS GRAMS                                11.462
  CO2 MASS GRAMS                               7499.02
  NOX MASS GRAMS                                52.101
  FUEL  KG (LB)                            2.439 (  5.38)
  KW HR (HP HR)                             9.08 ( 12.17)

TOTAL RESULTS
  BSHC   G/KW HR (G/HP HR)        .199(   .149) (   .15) (CONT)    90 MM FLTR NUMBERS          2979.0-257  P90-
  BSCO   G/KW HR (G/HP HR)       1.263(   .942) (   .94)           90 MM FLTR WT. GAINS (MG)     1.398          .000
  BSNOX  G/KW HR (G/HP HR)       5.741(  4.281) (  4.28) (CONT)    PARTICULATE GRAMS/TEST                .761
  PART.  G/KW HR (G/HP HR)        .084(   .063) (   .06)
  BSFC  KG/KW HR (LB/HP HR)       .269(   .442)
  WORK      KW HR (HP HR)         9.08(  12.17)
  BSCO2  G/KW HR (G/HP HR)        826. (   616.)
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# APPENDIX B

# DETAILED $C_1$ - $C_{12}$ SPECIATION RESULTS

TEST FUEL: 2-D, NO CATALYST
ENGINE: 1995 CUMMINS
TEST DATE: 10/31/95
TEST FUEL: EM-2045-F

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 9 | 0.7 | 0.2 | 1 | 0.1 | 0.0 | 0.2 | 0.0 |
| ETHYLENE | 427 | 33.7 | 245.7 | 314 | 24.9 | 181.2 | 26.1 | 190.5 |
| PROPANE | 62 | 4.9 | 2.3 | 0 | 0.0 | 0.0 | 0.7 | 0.3 |
| PROPYLENE | 133 | 10.5 | 98.8 | 97 | 7.7 | 72.4 | 8.1 | 76.2 |
| ACETYLENE | 117 | 9.3 | 4.6 | 88 | 7.0 | 3.5 | 7.3 | 3.6 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-BUTENE | 6 | 0.5 | 4.8 | 5 | 0.4 | 3.8 | 0.4 | 3.9 |
| 1-BUTENE | 35 | 2.8 | 24.8 | 26 | 2.1 | 18.4 | 2.2 | 19.3 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 31 | 2.4 | 12.8 | 23 | 1.8 | 9.8 | 1.9 | 10.2 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 35 | 2.8 | 30.1 | 28 | 2.2 | 24.4 | 2.3 | 25.2 |
| 2-METHYLPROPANE (ISOBUTANE) | 113 | 8.9 | 10.8 | 0 | 0.0 | 0.0 | 1.3 | 1.5 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 4 | 0.3 | 3.4 | 3 | 0.3 | 2.7 | 0.3 | 2.8 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 18 | 1.4 | 2.0 | 10 | 0.8 | 1.1 | 0.9 | 1.2 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 87 | 6.9 | 42.7 | 66 | 5.2 | 32.5 | 5.5 | 34.0 |
| 2-METHYL-1-BUTENE | 7 | 0.6 | 2.8 | 5 | 0.4 | 2.0 | 0.4 | 2.1 |
| PENTANE | 5 | 0.4 | 0.4 | 3 | 0.3 | 0.3 | 0.3 | 0.3 |
| UNIDENTIFIED C5 OLEFINS | 5 | 0.4 | 3.7 | 6 | 0.4 | 3.8 | 0.4 | 3.8 |
| 2-METHYL-1,3-BUTADIENE | 7 | 0.5 | 4.9 | 4 | 0.3 | 3.2 | 0.4 | 3.4 |
| TRANS-2-PENTENE | 3 | 0.3 | 2.4 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 3,3-DIMETHYL-1-BUTENE | 0 | 0.8 | 0.8 | 0 | 0.0 | 0.5 | 0.8 | 0.5 |
| CIS-2-PENTENE | 0 | 0.0 | 0.8 | 0 | 0.8 | 0.8 | 0.5 | 0.8 |
| 2-METHYL-2-BUTENE | 0 | 0.3 | 0.8 | 0 | 0.3 | 1.6 | 0.3 | 1.6 |
| CYCLOPENTADIENE | 0 | 0.3 | 0.8 | 0 | 0.8 | 0.2 | 0.3 | 0.3 |
| 2,2-DIMETHYLBUTANE | 0 | 0.0 | 0.8 | 0 | 0.0 | 0.2 | 0.5 | 0.8 |
| CYCLOPENTENE | 0 | 0.2 | 1.9 | 0 | 0.0 | 0.2 | 0.8 | 0.3 |
| 4-METHYL-1-PENTENE | 0 | 0.0 | 1.9 | 0 | 0.0 | 0.2 | 0.3 | 0.3 |
| 3-METHYL-1-PENTENE | 0 | 0.8 | 0.8 | 0 | 0.0 | 0.8 | 0.8 | 0.8 |
| CYCLOPENTANE | 0 | 0.8 | 0.5 | 0 | 0.0 | 0.8 | 0.8 | 0.5 |
| 2,3-DIMETHYLBUTANE | 0 | 0.0 | 0.5 | 0 | 0.0 | 0.3 | 0.3 | 0.3 |
| MTBE | 0 | 0.0 | 0.5 | 0 | 0.8 | 0.8 | 0.5 | 0.5 |
| 2,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.5 | 0 | 0.0 | 0.8 | 0.8 | 0.8 |
| 4-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.8 | 0 | 0.0 | 0.8 | 0.8 | 0.8 |
| 2-METHYLPENTANE | 0 | 0.3 | 0.5 | 0 | 0.3 | 0.3 | 0.3 | 0.3 |
| 4-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.8 | 0 | 0.0 | 0.5 | 0.5 | 0.8 |
| 3-METHYLPENTANE | 0 | 0.3 | 0.5 | 0 | 0.0 | 0.5 | 0.3 | 0.5 |
| 2-METHYL-1-PENTENE | 7 | 0.3 | 0.5 | 0 | 0.0 | 0.5 | 0.5 | 1.7 |
| 1-HEXENE | 7 | 0.6 | 0.5 | 0 | 0.0 | 0.5 | 0.5 | 1.7 |
| HEXANE | 0 | 0.3 | 0.3 | 0 | 0.0 | 0.5 | 0.2 | 0.2 |
| UNIDENTIFIED C6 OLEFINS | 38 | 0.8 | 20.0 | 24 | 1.9 | 12.8 | 2.1 | 13.9 |
| TRANS-3-HEXENE | 0 | 0.8 | 0.8 | 0 | 0.0 | 0.5 | 0.5 | 0.8 |
| CIS-3-HEXENE | 0 | 0.8 | 0.8 | 0 | 0.0 | 0.5 | 0.5 | 0.8 |
| TRANS-2-HEXENE | 0 | 0.0 | 0.8 | 0 | 0.0 | 0.5 | 0.5 | 0.8 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 3 | 0.2 | 0.3 | 3 | 0.2 | 0.3 | 0.2 | 0.3 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 4 | 0.3 | 0.5 | 3 | 0.2 | 0.4 | 0.2 | 0.4 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 7 | 0.5 | 0.7 | 6 | 0.5 | 0.7 | 0.5 | 0.7 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 4 | 0.3 | 1.9 | 0.3 | 1.6 |
| BENZENE | 48 | 3.8 | 1.6 | 33 | 2.6 | 1.1 | 2.8 | 1.2 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXANE | 3 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,3-DIMETHYLPENTANE | 3 | 0.[illegible] | 0.2 | [illegible] | 0.2 | 0.3 | 0.[illegible] | 0.[illegible] |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | 3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,3-DIMETHYLCYCLOPENTANE | 3 | 0.0 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLPENTANE | 3 | 0.0 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.3 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 3 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,2,4-TRIMETHYLPENTANE | 30 | 2.4 | 2.2 | 30 | 2.4 | 2.2 | 2.4 | 2.2 |
| 2-METHYL-1-HEXENE | 0 | 0.0 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-3-HEPTENE | 3 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| HEPTANE | 3 | 0.3 | 0.2 | 0 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| UNIDENTIFIED C7 | 13 | [illegible].3 | 0.6 | 7 | 0.6 | [illegible].7 | 0.7 | [illegible].9 |
| 2-METHYL-2-HEXENE | 3 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| TRANS-2-HEPTENE | 3 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,4,4-TRIMETHYL-1-PENTENE | 3 | 0.0 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-2-PENTENE | 3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 3 | 0.3 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,2-DIMETHYLHEXANE | 3 | 0.3 | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 3 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,4-DIMETHYLHEXANE | 3 | 0.3 | 0.6 | [illegible] | 0.0 | 0.6 | 0.0 | 0.2 |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 3 | 0.3 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 3,3-DIMETHYLHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,3,3-TRIMETHYLPENTANE | 2 | 0.3 | 0.2 | [illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| TOLUENE | 54 | [illegible].3 | 11.7 | 2 | 0.[illegible] | 0.[illegible] | 0.8 | 2.1 |
| 2,3-DIMETHYLHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEPTANE | 3 | 0.3 | 0.0 | [illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| 3,4-DIMETHYLHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4,4-TETRAMETHYLPENTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYLHEPTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.0 | 0.3 | 0.4 |
| 1-OCTENE | [illegible] | 0.4 | [illegible].4 | [illegible] | 0.4 | [illegible] | 0.4 | 1.1 |
| TRANS-4-OCTENE | 0 | 0.4 | 0.4 | 0 | 0.4 | 0.0 | 0.4 | 0.4 |
| OCTANE | 6 | 0.5 | 0.3 | 7 | 0.6 | 0.3 | 0.[illegible] | 0.3 |
| UNIDENTIFIED C8 | 10 | 0.4 | 2.6 | 5 | 0.4 | [illegible] | 0.[illegible] | [illegible].4 |
| TRANS-2-OCTENE | 0 | 0.4 | 0.4 | 0 | 0.3 | 0.0 | 0.4 | 0.4 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.4 | 0.4 | 0 | 0.4 | 0.0 | 0.4 | 0.4 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.4 | 0.4 | 0 | 0.4 | 0.0 | 0.0 | 0.4 |
| CIS-2-OCTENE | 0 | 0.4 | 0.4 | 0 | 0.4 | 0.0 | 0.0 | 0.4 |
| 2,3,5-TRIMETHYLHEXANE | 0 | 0.4 | 0.4 | 0 | 0.3 | 0.0 | 0.4 | 0.4 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.4 | 0.4 | 0 | 0.3 | 0.0 | 0.3 | 0.4 |
| 2-METHYL-2-ETHYLHEPTANE | 0 | 0.4 | 0.4 | 0 | 0.4 | 0.0 | 0.4 | 0.4 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.4 | 0.4 | 0 | 0.3 | 0.0 | 0.3 | 0.4 |
| 4,4-DIMETHYLHEPTANE | 0 | 0.4 | 0.4 | 0 | 0.4 | 0.0 | 0.3 | 0.4 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | 6 | 0.5 | 0.4 | 5 | 0.4 | 0.7 | 0.4 | 0.4 |
| ETHYLCYCLOHEXANE | 0 | 0.4 | 0.4 | [illegible] | 0.3 | 0.[illegible] | 0.2 | 0.4 |
| PROPYLCYCLOHEXANE | 0 | 0.4 | 0.4 | 0 | 0.4 | 0.0 | 0.4 | 0.4 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.4 | 0.4 | 0 | 0.4 | 0.0 | 0.3 | 0.4 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.4 | 0.4 | 0 | 0.4 | 0.0 | 0.4 | 0.4 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.4 | 0.4 | 0 | 0.4 | 0.0 | 0.4 | 0.4 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.4 | 0.4 | 0 | 0.3 | 0.0 | 0.4 | 0.4 |
| 3,3-DIMETHYLHEPTANE | 0 | 0.4 | 0.4 | 0 | 0.3 | 0.0 | 0.4 | 0.4 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.4 | 0.4 | 0 | 0.3 | 0.0 | 0.3 | 0.4 |
| ETHYLBENZENE | [illegible] | 0.4 | [illegible].4 | 8 | 0.4 | [illegible].8 | 0.4 | 1.8 |
| 2,3-DIMETHYLHEPTANE | 0 | 0.4 | 0.3 | 0 | 0.4 | 0.0 | 0.3 | 0.4 |
| m-& p-XYLENE | 15 | 1.2 | 8.4 | 13 | [illegible].3 | 7.7 | [illegible].3 | 7.8 |
| 4-METHYLOCTANE | 0 | 0.4 | 0.4 | 0 | 0.3 | 0.0 | 0.3 | 0.4 |
| 2-METHYLOCTANE | [illegible] | 0.3 | 0.3 | 0 | 0.3 | 0.[illegible] | 0.3 | 0.3 |
| 3-METHYLOCTANE | 0 | 0.4 | 0.4 | 0 | 0.4 | 0.0 | 0.4 | 0.4 |
| STYRENE | 0 | 0.4 | 0.4 | 0 | 0.4 | 0.0 | 0.4 | 0.4 |
| o-XYLENE | 11 | 0.4 | 5.6 | 11 | 0.4 | 5.7 | 0.4 | [illegible].4 |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.4 | 0.4 | 0 | 0.4 | 0.0 | 0.3 | 0.4 |
| 1-NONENE | 6 | 0.4 | 0.4 | 5 | 0.4 | 0.8 | 0.4 | 0.4 |
| NONANE | 10 | 0.4 | 0.4 | 13 | 0.4 | 0.0 | 0.3 | 0.4 |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.4 | 0.4 | 0 | 0.4 | 0.0 | 0.3 | 0.4 |
| 2,2-DIMETHYLOCTANE | [illegible] | 0.3 | 0.3 | [illegible] | 0.2 | 0.[illegible] | 0.2 | 0.4 |
| 2,4-DIMETHYLOCTANE | 6 | 0.5 | 0.5 | 0 | 0.3 | 0.[illegible] | 0.3 | 0.3 |
| n-PROPYLBENZENE | [illegible] | 0.4 | 0.8 | [illegible] | 0.3 | 0.[illegible] | 0.3 | 0.5 |
| 1-METHYL-3-ETHYLBENZENE | 6 | 0.4 | [illegible].4 | [illegible] | 0.4 | 3.1 | 0.4 | [illegible].4 |
| 1-METHYL-4-ETHYLBENZENE | 5 | 0.4 | 2.6 | [illegible] | 0.4 | [illegible].7 | 0.4 | [illegible].4 |
| 1,3,5-TRIMETHYLBENZENE | 5 | 0.4 | 4.3 | [illegible] | 0.4 | [illegible].8 | 0.4 | [illegible].4 |
| 1-METHYL-2-ETHYLBENZENE | 4 | 0.3 | [illegible].3 | 0 | 0.4 | 0.0 | 0.3 | 0.3 |
| 1,2,4-TRIMETHYLBENZENE | 11 | 1.1 | 10.1 | 12 | 0.3 | 8.[illegible] | [illegible].3 | 8.5 |
| DECANE | 7 | 0.5 | 4.3 | 7 | 0.6 | 0.[illegible] | 0.3 | 0.3 |
| ISOBUTYLBENZENE | 7 | 0.5 | 1.2 | 7 | 0.6 | [illegible].0 | 0.6 | [illegible].4 |
| METHYLPROPYLBENZENE | 0 | 0.4 | 0.4 | 0 | 0.3 | 0.0 | 0.3 | 0.4 |
| S-BUTYLBENZENE | 0 | 0.5 | 0.4 | 0 | 0.3 | 0.0 | 0.3 | 0.4 |
| 1-METHYL-3-ISOPROPYLBENZENE | 5 | 0.4 | 2.5 | 0 | 0.0 | 0.0 | 0.1 | 0.4 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 7 | 0.5 | 3.1 | 4 | 0.3 | 1.7 | 0.3 | 1.9 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 3 | 0.2 | 1.6 | 3 | 0.2 | 1.5 | 0.2 | 1.5 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 4 | 0.3 | 2.0 | 3 | 0.2 | 1.6 | 0.3 | 1.6 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 6 | 0.4 | 4.0 | 0 | 0.0 | 0.0 | 0.1 | 0.6 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 3 | 0.3 | 2.4 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | [illegible] | 0.2 | 2.2 | 0 | 0.0 | 0.0 | 0.0 | 0.6 |
| UNDECANE | 26 | 2.1 | 0.9 | 21 | [illegible] | [illegible] | 1.7 | 0.6 |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.6 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 0 | 9.6 | 0.0 | 0 | 0.0 | 0.0 | 0.6 | 0.6 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.6 | 0.6 |
| 3,4 DIMETHYLCUMENE | 0 | 9.6 | 0.0 | 0 | 0.0 | 0.0 | 0.6 | 0.6 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | [illegible] | 0.3 | [illegible] | [illegible] | [illegible] | [illegible] | 0.6 | 1.9 |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.6 | 0.6 |
| N-PENT-BENZENE | 8 | 0.6 | 1.1 | 7 | 0.6 | 0.9 | 0.6 | [illegible] |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.6 | 0.6 |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.6 | 0.6 |
| DODECANE | 15 | [illegible] | 0.6 | 22 | 1.7 | [illegible] | 1.7 | 4.5 |
| UNIDENTIFIED C9-C12+ | 122 | 9.6 | 36.6 | 141 | 11.2 | 42.6 | 11.0 | 41.7 |
| FORMALDEHYDE | 553 | 43.6 | 312.1 | 365 | 28.9 | 206.8 | 31.0 | 221.8 |
| ACETALDEHYDE | 196 | 15.4 | 85.2 | 126 | 10.0 | 55.1 | 10.8 | 59.4 |
| ACROLEIN | 15 | [illegible] | [illegible] | [illegible] | 1.7 | [illegible] | 0.6 | 5.1 |
| ACETONE | 53 | [illegible] | 2.3 | 30 | 2.4 | [illegible] | [illegible] | 1.5 |
| PROPIONALDEHYDE | 31 | 2.1 | [illegible] | 24 | [illegible] | 12.4 | [illegible] | 12.9 |
| CROTONALDEHYDE | 82 | 6.0 | 34.9 | 53 | 4.2 | 22.7 | 4.5 | 24.4 |
| ISOBUTYRALDEHYDE | 15 | [illegible] | 6.1 | 8 | 0.6 | 3.4 | 1.7 | 1.7 |
| METHYL ETHYL KETONE | 15 | [illegible] | 1.1 | 8 | 0.6 | 0.8 | 1.7 | 0.6 |
| BENZALDEHYDE | 21 | 1.7 | 10.9 | 14 | 1.1 | -0.6 | 1.2 | 0.6 |
| HEXANALDEHYDE | 20 | 1.6 | 5.9 | 12 | 0.9 | 3.5 | 1.0 | 3.8 |
|  |  |  |  |  |  |  |  |  |
| SUMMED SPECIATED VALUES | 2717 | 214 | 1132 | 1821 | 144 | 793 | 154.3 | 841.9 |

TEST FUEL: 2-D, WITH CATALYST
ENGINE: 1995 CUMMINS
TEST DATE: 11/3/95
TEST FUEL: EM-2045-F

| | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| COMPOUND | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 18 | 1.4 | 0.0 | 4 | 0.3 | 0.0 | 0.4 | 0.0 |
| ETHANE | 8 | 0.6 | 0.2 | 5 | 0.4 | 0.1 | 0.4 | 0.1 |
| ETHYLENE | 536 | 42.6 | 310.8 | 338 | 27.1 | 197.8 | 29.4 | 214.0 |
| PROPANE | 0 | 0.0 | 0.0 | 4 | 0.4 | 0.2 | 0.3 | 0.1 |
| PROPYLENE | 172 | 13.6 | 128.2 | 104 | 8.4 | 78.9 | 9.1 | 85.9 |
| ACETYLENE | 121 | 9.6 | 4.8 | 72 | 5.8 | 2.9 | 6.4 | 3.2 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 1 | 0.1 | 0.1 | 1 | 0.1 | 0.1 | 0.1 | 0.1 |
| TRANS-2-BUTENE | 9 | 0.8 | 7.5 | 6 | 0.5 | 5.0 | 0.5 | 5.4 |
| 1-BUTENE | 41 | 3.3 | 29.1 | 24 | 1.9 | 16.9 | 2.1 | 18.6 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 38 | 3.1 | 16.2 | 24 | 1.9 | 10.3 | 2.1 | 11.1 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 43 | 3.4 | 37.2 | 26 | 2.1 | 23.1 | 2.3 | 25.1 |
| 2-METHYLPROPANE (ISOBUTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 7 | 0.6 | 5.8 | 5 | 0.4 | 4.2 | 0.4 | 4.5 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 24 | 1.9 | 11.6 | 13 | 1.1 | 6.6 | 1.2 | 7.4 |
| 2-METHYL-1-BUTENE | 15 | 1.2 | 5.7 | 7 | 0.6 | 2.9 | 0.7 | 3.3 |
| PENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C5 OLEFINS | 7 | 0.5 | 4.6 | 0 | 0.0 | 0.0 | 0.1 | 0.7 |
| 2-METHYL-1,3-BUTADIENE | 8 | 0.7 | 6.0 | 5 | 0.4 | 3.4 | 0.4 | 3.8 |
| TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 3 | 0.3 | 2.4 | 0.2 | 2.1 |
| 3,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.4 | 0.0 | 0.0 |
| CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.4 | 0.0 | 0.0 |
| 2-METHYL-2-BUTENE | 8 | 0.6 | 0.0 | [illegible] | 0.0 | 2.5 | 0.0 | 2.7 |
| CYCLOPENTADIENE | 6 | 0.[illegible] | 3.7 | [illegible] | 0.0 | [illegible].4 | 0.0 | 2.9 |
| 2,2-DIMETHYLBUTANE | 0 | 0.0 | 0.0 | 8 | 0.6 | 0.4 | 0.[illegible] | 0.0 |
| CYCLOPENTENE | 0 | 0.[illegible] | 2.2 | 6 | 0.6 | 3.6 | 0.0 | 3.4 |
| 4-METHYL-1-PENTENE | 6 | 0.[illegible] | 2.1 | 3 | 0.2 | 1.1 | 0.3 | [illegible].2 |
| 3-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.4 | 0.0 | 0.0 |
| CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.4 | 0.0 | 0.0 |
| 2,3-DIMETHYLBUTANE | 15 | 1.2 | 1.2 | 8 | 2.7 | 0.7 | 0.7 | 0.8 |
| MTBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 2,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.4 | 0.0 | 2.0 |
| 2-METHYLPENTANE | 0 | 0.[illegible] | 0.[illegible] | [illegible] | 0.[illegible] | 0.4 | 0.3 | 0.0 |
| 4-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLPENTANE | 12 | 0.9 | [illegible].0 | [illegible] | 0.[illegible] | 0.4 | 0.3 | 0.6 |
| 2-METHYL-1-PENTENE | 10 | 0.8 | [illegible] | 0 | 0.3 | 1.3 | 0.0 | 1.6 |
| 1-HEXENE | 10 | 0.8 | [illegible] | 0 | 0.3 | 1.3 | 0.0 | 1.6 |
| HEXANE | 6 | 0.0 | 0.0 | 0 | 0.0 | 0.4 | 0.[illegible] | 0.[illegible] |
| UNIDENTIFIED C6 OLEFINS | 25 | [illegible].0 | 13.3 | [illegible] | 0.0 | [illegible].0 | 0.6 | 0.[illegible] |
| TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.4 | 0.0 | 0.0 |
| TRANS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.4 | 0.0 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 4 | 0.3 | 0.5 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BENZENE | 60 | 4.8 | 2.0 | 35 | 2.8 | 1.2 | 3.1 | 1.3 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLPENTANE | [illegible] | 0.4 | 0.6 | 7 | 0.6 | 0.8 | 0.[illegible] | 0.8 |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| CIS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLPENTANE | 8 | 0.6 | 0.6 | 4 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| 2-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-3-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEPTANE | [illegible] | 0.3 | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C7 | 11 | 0.9 | 4.1 | 5 | 0.[illegible] | [illegible].8 | 0.[illegible] | 2.1 |
| 2-METHYL-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | [illegible].0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEXANE | 5 | 0.4 | 0.6 | 0 | 0.4 | 0.0 | 0.[illegible] | 0.[illegible] |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOLUENE | 12 | [illegible].0 | 2.7 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.4 |
| 2,3-DIMETHYLHEXANE | 7 | 0.6 | 0.[illegible] | 0 | 0.0 | 0.0 | 0.[illegible] | 0.[illegible] |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4,4-TETRAMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-OCTENE | [illegible] | 0.[illegible] | 1.1 | [illegible] | 0.[illegible] | 0.6 | 0.3 | 0.8 |
| TRANS-4-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OCTANE | [illegible] | 0.[illegible] | 0.2 | [illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| UNIDENTIFIED C8 | [illegible] | 0.7 | 2.6 | [illegible] | 0.[illegible] | [illegible].0 | 0.[illegible] | [illegible] |
| TRANS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-ETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | [illegible] | 0.3 | [illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| ETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLBENZENE | 8 | 0.6 | 1.7 | [illegible] | 0.[illegible] | [illegible].0 | 0.[illegible] | [illegible] |
| 2,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| m-& p-XYLENE | 15 | 1.2 | 9.0 | [illegible] | 0.[illegible] | 5.1 | 0.6 | [illegible] |
| 4-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLOCTANE | 4 | 0.3 | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 3-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| STYRENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| o-XYLENE | 6 | 0.[illegible] | [illegible].8 | [illegible] | 0.[illegible] | [illegible].9 | 0.[illegible] | [illegible].0 |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-NONENE | 4 | 0.3 | 0.8 | [illegible] | 0.[illegible] | 0.7 | 0.[illegible] | 0.[illegible] |
| NONANE | 8 | 0.6 | 0.3 | 7 | 0.6 | 0.3 | 0.6 | 0.[illegible] |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLOCTANE | 3 | 0.3 | 0.3 | 0 | 0.0 | 0.3 | 0.0 | 0.0 |
| n-PROPYLBENZENE | 6 | 0.5 | 1.1 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.[illegible] |
| 1-METHYL-3-ETHYLBENZENE | [illegible] | 0.[illegible] | 3.1 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.[illegible] |
| 1-METHYL-4-ETHYLBENZENE | 4 | 0.3 | 2.1 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 1,3,5-TRIMETHYLBENZENE | 4 | 0.3 | 3.1 | 3 | 0.[illegible] | [illegible].6 | 0.[illegible] | [illegible] |
| 1-METHYL-2-ETHYLBENZENE | [illegible] | 0.7 | 2.6 | [illegible] | 0.[illegible] | [illegible].7 | 0.[illegible] | [illegible].8 |
| 1,2,4-TRIMETHYLBENZENE | 14 | 1.1 | 9.[illegible] | 8 | 0.[illegible] | [illegible].6 | 0.7 | [illegible] |
| DECANE | [illegible] | 0.7 | 0.3 | 7 | 0.[illegible] | 0.3 | 0.6 | 0.[illegible] |
| ISOBUTYLBENZENE | 8 | 0.7 | 1.2 | 6 | 0.[illegible] | [illegible].6 | 0.6 | [illegible].0 |
| METHYLPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S-BUTYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-ISOPROPYLBENZENE | 5 | 0.4 | 2.3 | 3 | 0.2 | 1.5 | 0.3 | 1.6 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP–HR | OZONE, MG/BHP–HR | MG | MG/BHP–HR | OZONE, MG/BHP–HR | MG/BHP–HR | OZONE, MG/BHP–HR |
| 1–METHYL–2–ISOPROPYLBENZENE | 4 | 0.4 | 2.1 | 0 | 0.0 | 0.0 | 0.1 | 0.3 |
| 1,3–DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4–DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–METHYL–3–N–PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–METHYL–4–N–PROPYLBENZENE | 4 | 0.3 | 2.0 | 4 | 0.3 | 2.0 | 0.3 | 2.0 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–METHYL–2–N–PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4–DIMETHYL–2–ETHYLBENZENE | 5 | 0.4 | 3.5 | 3 | 0.2 | 2.2 | 0.3 | 2.4 |
| 1,3–DIMETHYL–4–ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2–DIMETHYL–4–ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3–DIMETHYL–2–ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNDECANE | 23 | [illegible].8 | 0.8 | 19 | 1.5 | 0.6 | 4.5 | 0.[illegible] |
| 1,2–DIMETHYL–3–ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4,5–TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2–METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,5–TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT–1–BUT–2–METHYLBENZENE | [illegible] | 0.0 | 2.1 | [illegible] | 0.0 | 2.2 | 0.0 | 2.2 |
| 1,2,3,4–TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| N–PENT–BENZENE | 6 | 0.[illegible] | 0.8 | [illegible] | 0.0 | 0.[illegible] | 0.0 | 0.7 |
| TERT–1–BUT–3,5–DIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DODECANE | 13 | [illegible].0 | 0.0 | 11 | [illegible] | 0.0 | 1.1 | 0.0 |
| UNIDENTIFIED C9–C12+ | 46 | 3.7 | 13.9 | 11 | 3.3 | 12.5 | 3.3 | 12.7 |
| FORMALDEHYDE | 831 | 66.1 | 472.3 | 516 | 41.5 | 296.4 | 45.0 | 321.6 |
| ACETALDEHYDE | 390 | 31.0 | 171.1 | 237 | 19.1 | 105.4 | 20.8 | 114.7 |
| ACROLEIN | 46 | 3.2 | 21.7 | 11 | 0.9 | 6.1 | 1.2 | 8.0 |
| ACETONE | 124 | 9.9 | 5.5 | 71 | [illegible] | 3.2 | 6.[illegible] | 3.5 |
| PROPIONALDEHYDE | 65 | 5.2 | 33.6 | 39 | 3.1 | 20.3 | [illegible].0 | 22.2 |
| CROTONALDEHYDE | 65 | 7.6 | 41.0 | 50 | 0.0 | 21.7 | 4.5 | 24.5 |
| ISOBUTYRALDEHYDE | 25 | 2.0 | 10.3 | 12 | 1.0 | 5.3 | 1.1 | 6.0 |
| METHYL ETHYL KETONE | 25 | [illegible].0 | 2.3 | 12 | [illegible].0 | 3.2 | 1.1 | 1.3 |
| BENZALDEHYDE | 22 | [illegible].8 | 41.0 | 9 | 0.7 | –0.4 | 0.8 | 0.[illegible] |
| HEXANALDEHYDE | 12 | 0.9 | 3.6 | 8 | 0.7 | 2.5 | 0.7 | 2.7 |
|  |  |  |  |  |  |  |  |  |
| SUMMED SPECIATED VALUES | 3134 | 249 | 1447 | 1875 | 151 | 883 | 164.8 | 963.2 |

TEST FUEL: 2-D, NO CATALYST - Repeat
ENGINE: 1995 CUMMINS
TEST DATE: 11/8/95
TEST FUEL: EM-2045-F

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 39 | 3.1 | 0.0 | 241 | 19.7 | 0.3 | 17.3 | 0.3 |
| ETHANE | 9 | 0.7 | 0.2 | 7 | 0.5 | 0.1 | 0.6 | 0.1 |
| ETHYLENE | 463 | 37.5 | 273.5 | 358 | 29.3 | 213.6 | 30.5 | 222.1 |
| PROPANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLENE | 144 | 11.7 | 109.8 | 108 | 8.9 | 83.2 | 9.3 | 87.0 |
| ACETYLENE | 120 | 9.7 | 4.9 | 97 | 7.9 | 4.0 | 8.2 | 4.1 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-BUTENE | 7 | 0.5 | 5.4 | 5 | 0.4 | 4.3 | 0.4 | 4.4 |
| 1-BUTENE | 37 | 3.0 | 26.9 | 29 | 2.3 | 20.8 | 2.4 | 21.7 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 32 | 2.6 | 13.7 | 24 | 2.0 | 10.6 | 2.1 | 11.1 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 36 | 2.9 | 31.6 | 30 | 2.5 | 27.1 | 2.5 | 27.8 |
| 2-METHYLPROPANE (ISOBUTANE) | 2 | 0.2 | 0.2 | 1 | 0.1 | 0.1 | 0.1 | 0.1 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 5 | 0.4 | 3.9 | 4 | 0.3 | 3.4 | 0.3 | 3.4 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 36 | 2.9 | 18.3 | 14 | 1.2 | 7.3 | 1.4 | 8.9 |
| 2-METHYL-1-BUTENE | 12 | 1.0 | 4.9 | 7 | 0.6 | 2.8 | 0.6 | 3.1 |
| PENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C5 OLEFINS | 10 | 0.8 | 6.9 | 8 | 0.7 | 6.1 | 0.7 | 6.2 |
| 2-METHYL-1,3-BUTADIENE | 8 | 0.6 | 5.7 | 4 | 0.3 | 2.9 | 0.4 | 3.3 |
| TRANS-2-PENTENE | 4 | 0.3 | 2.7 | 0 | 0.0 | 0.0 | 0.0 | 0.4 |
| 3,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-BUTENE | 0 | 0.[illegible] | [illegible].0 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| CYCLOPENTADIENE | [illegible] | 0.0 | [illegible].0 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.2 |
| 2,2-DIMETHYLBUTANE | 5 | 0.0 | 0.[illegible] | 0 | 0.0 | 0.5 | 0.0 | 0.[illegible] |
| CYCLOPENTENE | [illegible] | 0.[illegible] | 2.1 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 4-METHYL-1-PENTENE | [illegible] | 0.0 | [illegible].0 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.[illegible] |
| 3-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.[illegible] | [illegible] | 0.3 | 1.1 |
| CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLBUTANE | 0 | 0.[illegible] | 0.[illegible] | 2 | 0.[illegible] | 0.2 | 0.2 | 0.2 |
| MTBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLPENTANE | [illegible] | 0.3 | 0.0 | 1 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.2 |
| 4-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-1-PENTENE | 7 | 0.6 | [illegible].6 | [illegible] | 0.0 | [illegible].0 | 0.0 | 1.9 |
| 1-HEXENE | 7 | 0.6 | [illegible].6 | [illegible] | 0.0 | [illegible].0 | 0.0 | [illegible].0 |
| HEXANE | [illegible] | 0.[illegible] | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C6 OLEFINS | 24 | 1.9 | 12.9 | 11 | 0.9 | 6.0 | [illegible].0 | [illegible].0 |
| TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.2 | 0.0 | 0.0 |
| CIS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.2 | 0.0 | 0.0 |
| TRANS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 0 | 0.0 | 0.1 | 1 | 0.1 | 0.1 | 0.1 | 0.1 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 0 | 0.0 | 0.0 | 8 | 0.7 | 0.9 | 0.6 | 0.7 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 6 | 0.5 | 2.8 | 0.4 | 2.4 |
| BENZENE | 52 | 4.2 | 1.8 | 39 | 3.2 | 1.3 | 3.4 | 1.4 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLPENTANE | 1 | 0.1 | [illegible] | [illegible] | [illegible] | 0.0 | [illegible] | 0.0 |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | [illegible] | 0.2 | [illegible] | [illegible] | 0.3 | 0.0 | 0.3 | 0.0 |
| CIS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLPENTANE | 14 | [illegible] | 1.1 | [illegible] | 0.8 | [illegible] | 0.8 | 0.8 |
| 2-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-3-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C7 | 14 | 0.9 | [illegible] | 13 | 1.1 | [illegible] | 1.1 | 4.7 |
| 2-METHYL-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | [illegible] |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEXANE | [illegible] | 0.0 | [illegible] | 0 | 0.0 | 0.0 | 0.1 | [illegible] |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOLUENE | 85 | 6.9 | 18.8 | 25 | [illegible] | [illegible] | 2.7 | 7.5 |
| 2,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEPTANE | [illegible] | [illegible] | [illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4,4-TETRAMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 4 | 0.3 | 0.6 | 3 | 0.2 | 0.4 | 0.2 | 0.4 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-OCTENE | 5 | 0.0 | 1.1 | 5 | 0.0 | [illegible] | 0.0 | 1.1 |
| TRANS-4-OCTENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OCTANE | 4 | 0.[illegible] | 0.[illegible] | 0 | 0.3 | 0.[illegible] | 0.[illegible] | 0.2 |
| UNIDENTIFIED C8 | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-OCTENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-OCTENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,5-TRIMETHYLHEXANE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-ETHYLHEPTANE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.[illegible] | 0.0 | [illegible] | 0.3 | 0.0 | 0.[illegible] | 0.0 |
| 4,4-DIMETHYLHEPTANE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | [illegible] | 0.0 | 0.[illegible] | 0 | 0.3 | 0.6 | 0.[illegible] | 0.6 |
| ETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEPTANE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEPTANE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLBENZENE | 5 | 0.0 | 1.1 | 0 | 0.3 | 0.9 | 0.0 | 0.9 |
| 2,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| m-& p-XYLENE | 13 | 1.1 | 8.0 | 10 | 0.8 | 6.3 | 0.9 | [illegible] |
| 4-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLOCTANE | [illegible] | 0.[illegible] | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| STYRENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| o-XYLENE | 5 | 0.5 | [illegible].0 | 5 | 0.0 | [illegible] | 0.0 | 2.7 |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-NONENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NONANE | 5 | 0.[illegible] | 0.0 | 8 | 0.6 | 0.[illegible] | 0.6 | 0.[illegible] |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLOCTANE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLOCTANE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| n-PROPYLBENZENE | 5 | 0.0 | 0.8 | [illegible] | 0.3 | 0.5 | 0.[illegible] | 0.6 |
| 1-METHYL-3-ETHYLBENZENE | 5 | 0.[illegible] | 3.5 | 0 | 0.0 | [illegible].6 | 0.0 | 2.7 |
| 1-METHYL-4-ETHYLBENZENE | 0 | 0.3 | 2.4 | [illegible] | 0.2 | 1.7 | 0.[illegible] | 1.8 |
| 1,3,5-TRIMETHYLBENZENE | 0 | 0.0 | [illegible].6 | 0 | 0.3 | 3.2 | 0.[illegible] | 3.2 |
| 1-METHYL-2-ETHYLBENZENE | 5 | 0.0 | [illegible] | [illegible] | 0.2 | [illegible].8 | 0.[illegible] | [illegible].9 |
| 1,2,4-TRIMETHYLBENZENE | 13 | [illegible].0 | 9.0 | 11 | 0.3 | [illegible].6 | 0.9 | [illegible].8 |
| DECANE | 8 | 0.[illegible] | 0.[illegible] | 9 | 0.8 | 0.0 | 0.7 | 0.[illegible] |
| ISOBUTYLBENZENE | 8 | 0.5 | 1.2 | 9 | 0.2 | [illegible] | 0.7 | [illegible] |
| METHYLPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S-BUTYLBENZENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-ISOPROPYLBENZENE | 5 | 0.4 | 2.6 | 4 | 0.3 | 2.0 | 0.4 | 2.1 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 5 | 0.4 | 2.5 | 5 | 0.4 | 2.2 | 0.4 | 2.2 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 3 | 0.2 | 1.5 | 3 | 0.2 | 1.6 | 0.2 | 1.6 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 4 | 0.4 | 2.3 | 3 | 0.3 | 1.7 | 0.3 | 1.8 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 5 | 0.4 | 3.3 | 5 | 0.4 | 3.8 | 0.4 | 3.7 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 3 | 0.3 | 2.3 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNDECANE | 26 | 2.1 | 0.9 | 27 | 2.2 | 0.9 | 2.2 | 0.9 |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 12 | [illegible] | [illegible] | 0.9 | 7.9 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | [illegible] | 0.0 | 2.3 | [illegible] | 0.4 | 2.3 | 0.0 | 2.3 |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENT-BENZENE | 8 | 0.6 | [illegible] | 7 | 0.6 | [illegible] | 0.6 | [illegible] |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DODECANE | 18 | 1.5 | 0.6 | 21 | 1.7 | 0.6 | 1.7 | 0.6 |
| UNIDENTIFIED C9-C12+ | 58 | [illegible] | 12.1 | 53 | 4.3 | 16.5 | [illegible] | 16.7 |
| FORMALDEHYDE | 592 | 48.0 | 343.4 | 376 | 30.7 | 219.7 | 33.2 | 237.4 |
| ACETALDEHYDE | 224 | 18.2 | 100.2 | 143 | 11.7 | 64.7 | 12.6 | 69.8 |
| ACROLEIN | 22 | [illegible] | 12.1 | 14 | 1.1 | 7.7 | [illegible] | [illegible] |
| ACETONE | 76 | 6.2 | 3.5 | 45 | 3.7 | 2.1 | [illegible] | 2.3 |
| PROPIONALDEHYDE | 58 | [illegible] | 28.8 | 31 | 2.5 | 16.5 | 2.1 | 18.3 |
| CROTONALDEHYDE | 94 | [illegible] | 41.2 | 61 | [illegible] | 27.2 | 5.4 | 29.2 |
| ISOBUTYRALDEHYDE | 18 | 1.5 | 7.7 | 14 | 0.9 | 4.7 | 1.0 | 5.1 |
| METHYL ETHYL KETONE | 18 | 1.5 | 1.7 | 11 | 0.9 | [illegible] | [illegible] | 1.1 |
| BENZALDEHYDE | 22 | [illegible] | -1.0 | 45 | [illegible] | -0.7 | [illegible] | -0.7 |
| HEXANALDEHYDE | 25 | 2.1 | 7.8 | 14 | 1.1 | 4.3 | 1.3 | 4.8 |
|  |  |  |  |  |  |  |  |  |
| SUMMED SPECIATED VALUES | 2611 | 212 | 1187 | 2040 | 167 | 836 | 173.2 | 886.5 |

TEST FUEL: REE, NO CATALYST
ENGINE: 1995 CUMMINS
TEST DATE: 11/9/95
TEST FUEL: EM-2126-F

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 7 | 0.6 | 0.1 | 3 | 0.3 | 0.1 | 0.3 | 0.1 |
| ETHYLENE | 441 | 37.3 | 272.2 | 292 | 24.8 | 181.0 | 26.6 | 194.0 |
| PROPANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLENE | 68 | 5.8 | 54.4 | 46 | 3.9 | 36.7 | 4.2 | 39.2 |
| ACETYLENE | 119 | 10.0 | 5.0 | 76 | 6.4 | 3.2 | 6.9 | 3.5 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-BUTENE | 2 | 0.2 | 2.0 | 2 | 0.1 | 1.5 | 0.2 | 1.6 |
| 1-BUTENE | 25 | 2.2 | 19.2 | 17 | 1.4 | 12.5 | 1.5 | 13.5 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 7 | 0.6 | 3.4 | 6 | 0.5 | 2.8 | 0.5 | 2.9 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 36 | 3.0 | 32.9 | 22 | 1.8 | 20.1 | 2.0 | 21.9 |
| 2-METHYLPROPANE (ISOBUTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 2 | 0.2 | 0.3 | 1 | 0.1 | 0.1 | 0.1 | 0.2 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 4 | 0.3 | 1.9 | 4 | 0.4 | 2.2 | 0.3 | 2.2 |
| 2-METHYL-1-BUTENE | 5 | 0.4 | 1.9 | 6 | 0.5 | 2.3 | 0.5 | 2.3 |
| PENTANE | 6 | 0.5 | 0.5 | 5 | 0.4 | 0.4 | 0.4 | 0.5 |
| UNIDENTIFIED C5 OLEFINS | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-1,3-BUTADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-PENTENE | [illegible] | 0.[illegible] | [illegible].0 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 2-METHYL-2-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTADIENE | 5 | 0.4 | 3.2 | 0 | 0.0 | 0.0 | 0.4 | 0.5 |
| 2,2-DIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTENE | [illegible] | 0.[illegible] | 1.8 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 4-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MTBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLPENTANE | 8 | 0.4 | 1.8 | 0 | 0.[illegible] | 0.[illegible] | 0.0 | 0.5 |
| 4-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLPENTANE | 6 | 0.[illegible] | 0.8 | 0 | 0.[illegible] | 0.[illegible] | 0.4 | 0.5 |
| 2-METHYL-1-PENTENE | 7 | 0.6 | 2.4 | 0 | 0.3 | 1.5 | 0.0 | 1.6 |
| 1-HEXENE | 7 | 0.6 | 2.4 | 0 | 0.[illegible] | [illegible].[illegible] | 0.0 | 1.6 |
| HEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C6 OLEFINS | 10 | 0.8 | 5.4 | 0 | 0.[illegible] | [illegible].[illegible] | 0.0 | 2.7 |
| TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 3 | 0.3 | 0.4 | 4 | 0.3 | 0.4 | 0.3 | 0.4 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 3 | 0.2 | 0.4 | 0.2 | 0.3 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 0 | 0.0 | 0.0 | 3 | 0.2 | 0.3 | 0.2 | 0.3 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BENZENE | 58 | 4.9 | 2.1 | 33 | 2.8 | 1.2 | 3.1 | 1.3 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.2 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLPENTANE | [illegible] | 0.[illegible] | 0.[illegible] | 2 | 0.2 | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.2 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLPENTANE | 27 | 2.3 | [illegible] | 15 | 1.3 | [illegible].2 | 1.4 | 1.3 |
| 2-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-3-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C7 | [illegible] | 2.3 | 1.5 | 3 | 0.[illegible] | 1.1 | 0.3 | [illegible] |
| 2-METHYL-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYLPENTANE | [illegible] | 0.2 | 0.3 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOLUENE | 30 | 2.5 | 7.0 | 30 | 2.6 | 7.1 | 2.6 | 7.0 |
| 2,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 3,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4,4-TETRAMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 3 | 0.3 | 0.6 | 0.3 | 0.5 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-OCTENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| TRANS-4-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.4 | 0.4 | 0.0 |
| UNIDENTIFIED C8 | 10 | 0.0 | [illegible].0 | 0 | 0.0 | 0.4 | 0.4 | 0.0 |
| TRANS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.4 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-ETHYLHEPTANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.4 | 0.4 | 0.0 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.4 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.4 | 0.4 | 0.0 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLBENZENE | 2 | 0.[illegible] | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 2,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| m-& p-XYLENE | [illegible] | 0.0 | [illegible].1 | 0 | 0.0 | [illegible].4 | 0.4 | 2.7 |
| 4-METHYLOCTANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.4 | 0.4 | 0.0 |
| 2-METHYLOCTANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.4 | 0.0 | 0.0 |
| 3-METHYLOCTANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| STYRENE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.4 | 0.0 | 0.0 |
| o-XYLENE | 0 | 0.0 | 2.4 | [illegible] | 0.0 | 2.5 | 0.4 | 2.5 |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| 1-NONENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| NONANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| 2,2-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.4 | 0.4 | 0.0 |
| 2,4-DIMETHYLOCTANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.4 | 0.0 | 0.0 |
| n-PROPYLBENZENE | 0 | 0.3 | 0.1 | 0 | 0.0 | 0.4 | 0.4 | 0.1 |
| 1-METHYL-3-ETHYLBENZENE | [illegible] | 0.3 | [illegible].1 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 1-METHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| 1,3,5-TRIMETHYLBENZENE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| 1,2,4-TRIMETHYLBENZENE | 0 | 0.[illegible] | [illegible].1 | [illegible] | 0.[illegible] | [illegible].4 | 0.[illegible] | 2.2 |
| DECANE | [illegible] | 0.[illegible] | 0.1 | [illegible] | 0.[illegible] | 0.4 | 0.[illegible] | 0.1 |
| ISOBUTYLBENZENE | [illegible] | 0.[illegible] | 0.1 | [illegible] | 0.[illegible] | 0.4 | 0.[illegible] | 0.0 |
| METHYLPROPYLBENZENE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| S-BUTYLBENZENE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| 1-METHYL-3-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 3 | 0.2 | 2.0 | 0.2 | 1.7 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DODECANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 23 | 1.9 | 17.7 | 1.7 | 15.1 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENT-BENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DODECANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C9-C12+ | 23 | 1.9 | 7.4 | 0 | 0.0 | 2.7 | 0.0 | 0.0 |
| FORMALDEHYDE | 329 | 27.9 | 199.4 | 229 | 19.5 | 139.5 | 20.7 | 148.1 |
| ACETALDEHYDE | 127 | 10.7 | 59.3 | 88 | 7.4 | 41.1 | 7.9 | 43.7 |
| ACROLEIN | 25 | 2.1 | 14.2 | 12 | [illegible].0 | 6.6 | 1.1 | 7.7 |
| ACETONE | 3 | 0.2 | 0.1 | 1 | 0.1 | 0.1 | 0.1 | 0.1 |
| PROPIONALDEHYDE | 22 | 1.8 | 12.0 | 20 | 1.7 | 10.9 | 1.7 | 11.1 |
| CROTONALDEHYDE | 19 | 1.6 | 8.7 | 13 | 1.1 | 6.2 | 1.2 | 6.5 |
| ISOBUTYRALDEHYDE | 8 | 0.7 | 3.6 | 6 | 0.5 | 2.5 | 0.5 | 2.7 |
| METHYL ETHYL KETONE | 8 | 0.7 | 0.8 | 6 | 0.5 | 0.6 | 0.5 | 0.6 |
| BENZALDEHYDE | 6 | 0.5 | -0.3 | 5 | 0.4 | -0.2 | 0.4 | -0.2 |
| HEXANALDEHYDE | 8 | 0.7 | 2.7 | 4 | 0.3 | 1.2 | 0.4 | 1.4 |
|  |  |  |  |  |  |  |  |  |
| SUMMED SPECIATED VALUES | 1519 | 129 | 750 | 1035 | 88 | 521 | 93.8 | 553.5 |

TEST FUEL: REE, WITH CATALYST
ENGINE: 1995 CUMMINS
TEST DATE: 11/10/95
TEST FUEL: EM-2126-F

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 88 | 7.5 | 0.1 | 38 | 3.2 | 0.0 | 3.8 | 0.1 |
| ETHANE | 6 | 0.5 | 0.1 | 0 | 0.0 | 0.0 | 0.1 | 0.0 |
| ETHYLENE | 437 | 37.5 | 273.0 | 284 | 24.3 | 177.2 | 26.2 | 190.9 |
| PROPANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLENE | 62 | 5.3 | 49.7 | 42 | 3.6 | 33.9 | 3.8 | 36.2 |
| ACETYLENE | 98 | 8.4 | 4.2 | 51 | 4.4 | 2.2 | 4.9 | 2.5 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 2 | 0.2 | 0.2 | 61 | 5.2 | 5.3 | 4.5 | 4.6 |
| TRANS-2-BUTENE | 3 | 0.2 | 2.3 | 3 | 0.2 | 2.3 | 0.2 | 2.3 |
| 1-BUTENE | 20 | 1.8 | 15.6 | 12 | 1.0 | 9.3 | 1.1 | 10.2 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 6 | 0.5 | 2.7 | 6 | 0.5 | 2.9 | 0.5 | 2.9 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 28 | 2.4 | 25.9 | 16 | 1.3 | 14.6 | 1.5 | 16.2 |
| 2-METHYLPROPANE (ISOBUTANE) | 0 | 0.0 | 0.0 | 4 | 0.3 | 0.4 | 0.3 | 0.3 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 2 | 0.2 | 1.8 | 2 | 0.2 | 1.7 | 0.2 | 1.7 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 10 | 0.8 | 1.2 | 18 | 1.5 | 2.1 | 1.4 | 2.0 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 4 | 0.4 | 2.3 | 1 | 0.1 | 0.6 | 0.1 | 0.9 |
| 2-METHYL-1-BUTENE | 12 | 1.0 | 5.1 | 4 | 0.3 | 1.6 | 0.4 | 2.1 |
| PENTANE | 3 | 0.3 | 0.3 | 5 | 0.4 | 0.5 | 0.4 | 0.4 |
| UNIDENTIFIED C5 OLEFINS | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-1,3-BUTADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.4 |
| CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLBUTANE | 5 | 0.[illegible] | 0.0 | 1 | 0.6 | 0.[illegible] | 0.6 | 0.[illegible] |
| CYCLOPENTENE | 5 | 0.[illegible] | 1.9 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 4-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTANE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLBUTANE | 1 | 0.1 | 0.1 | 1 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.4 |
| MTBE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.4 |
| 2,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.4 |
| 4-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLPENTANE | [illegible] | 0.[illegible] | 0.[illegible] | [illegible] | 0.3 | 0.0 | 0.3 | 0.4 |
| 4-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLPENTANE | [illegible] | 0.[illegible] | 0.2 | [illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| 2-METHYL-1-PENTENE | 5 | 0.0 | 1.9 | [illegible] | 0.[illegible] | 0.8 | 0.[illegible] | [illegible].0 |
| 1-HEXENE | [illegible] | 0.0 | [illegible] | [illegible] | 0.[illegible] | 0.8 | 0.[illegible] | [illegible].0 |
| HEXANE | 0 | 0.3 | 0.3 | 5 | 0.[illegible] | 0.0 | 0.4 | 0.4 |
| UNIDENTIFIED C6 OLEFINS | 12 | [illegible].0 | 6.7 | 8 | 0.7 | 4.6 | 0.[illegible] | [illegible] |
| TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.4 |
| TRANS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 3 | 0.3 | 0.4 | 5 | 0.4 | 0.6 | 0.4 | 0.6 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 3 | 0.3 | 0.5 | 4 | 0.4 | 0.6 | 0.3 | 0.6 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BENZENE | 54 | 4.6 | 1.9 | 32 | 2.7 | 1.1 | 3.0 | 1.3 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLPENTANE | [illegible] | 0.4 | 0.6 | 8 | 0.7 | [illegible].0 | 0.6 | [illegible].0 |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLPENTANE | 7 | 0.6 | 0.6 | [illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| 2-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-3-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEPTANE | 7 | 0.6 | 0.6 | 0 | 0.0 | 0.0 | 0.1 | 0.[illegible] |
| UNIDENTIFIED C7 | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYLPENTANE | [illegible] | 0.[illegible] | 0.6 | [illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| TOLUENE | 98 | 8.4 | 23.0 | 21 | [illegible].8 | [illegible].8 | 2.7 | 7.4 |
| 2,3-DIMETHYLHEXANE | 7 | 0.6 | 0.8 | 0 | 0.0 | 0.0 | 0.1 | 0.[illegible] |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4,4-TETRAMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 4 | 0.3 | 0.6 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-4-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C8 | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-ETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLBENZENE | [illegible] | 0.[illegible] | 0.6 | [illegible] | 0.3 | 0.7 | 0.[illegible] | 0.[illegible] |
| 2,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| m-& p-XYLENE | 6 | 0.5 | [illegible].6 | 6 | 0.5 | 4.0 | 0.[illegible] | [illegible].0 |
| 4-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| STYRENE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| o-XYLENE | [illegible] | 0.[illegible] | 1.3 | 0 | 0.3 | 4.0 | 0.[illegible] | 1.9 |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-NONENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NONANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| n-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3,5-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DECANE | [illegible] | 0.[illegible] | 0.1 | [illegible] | 0.3 | 0.1 | 0.[illegible] | 0.[illegible] |
| ISOBUTYLBENZENE | [illegible] | 0.[illegible] | 0.[illegible] | [illegible] | 0.3 | 0.5 | 0.[illegible] | 0.[illegible] |
| METHYLPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S-BUTYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 3 | 0.2 | 2.1 | 0.2 | 1.8 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNDECANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 14 | 1.2 | 10.6 | 34 | [illegible].9 | 26.3 | 2.7 | 24.1 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENT-BENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DODECANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C9-C12+ | 0 | 0.[illegible] | 2.1 | 1 | 0.0 | 0.[illegible] | 0.1 | 0.0 |
| FORMALDEHYDE | 382 | 32.8 | 234.3 | 273 | 23.3 | 166.7 | 24.7 | 176.3 |
| ACETALDEHYDE | 225 | 19.3 | 106.6 | 160 | 13.7 | 75.4 | 14.5 | 79.9 |
| ACROLEIN | 23 | [illegible].0 | 1[illegible].6 | 13 | [illegible] | 7.7 | 1.3 | [illegible] |
| ACETONE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPIONALDEHYDE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CROTONALDEHYDE | 11 | [illegible].0 | 5.2 | [illegible] | [illegible] | 3.0 | 0.6 | 3.3 |
| ISOBUTYRALDEHYDE | 0 | 0.3 | [illegible] | 1 | 0.[illegible] | 0.0 | 0.1 | 0.6 |
| METHYL ETHYL KETONE | 0 | 0.[illegible] | 0.4 | 1 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| BENZALDEHYDE | [illegible] | 0.0 | -0.2 | [illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| HEXANALDEHYDE | 9 | 0.8 | 3.1 | 4 | 0.4 | 1.4 | 0.4 | 1.6 |
| | | | | | | | | |
| SUMMED SPECIATED VALUES | 1713 | 147 | 811 | 1171 | 100 | 562 | 106.8 | 597.4 |

TEST FUEL: REE, WITH CATALYST - Repeat
ENGINE: 1995 CUMMINS
TEST DATE: 11/13/95
TEST FUEL: EM-2126-F

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 8 | 0.7 | 0.0 | 0 | 0.0 | 0.0 | 0.1 | 0.0 |
| ETHANE | 6 | 0.5 | 0.1 | 0 | 0.0 | 0.0 | 0.1 | 0.0 |
| ETHYLENE | 532 | 46.5 | 339.2 | 302 | 26.3 | 192.0 | 29.2 | 213.0 |
| PROPANE | 0 | 0.0 | 0.0 | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| PROPYLENE | 76 | 6.7 | 62.6 | 44 | 3.8 | 35.7 | 4.2 | 39.5 |
| ACETYLENE | 137 | 12.0 | 6.0 | 77 | 6.7 | 3.4 | 7.5 | 3.7 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-BUTENE | 2 | 0.2 | 2.1 | 2 | 0.2 | 1.9 | 0.2 | 2.0 |
| 1-BUTENE | 29 | 2.6 | 22.7 | 16 | 1.4 | 12.7 | 1.6 | 14.2 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 7 | 0.6 | 3.4 | 6 | 0.5 | 2.8 | 0.5 | 2.9 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 44 | 3.8 | 41.9 | 25 | 2.2 | 23.5 | 2.4 | 26.1 |
| 2-METHYLPROPANE (ISOBUTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 12 | 1.0 | 1.4 | 1 | 0.1 | 0.1 | 0.2 | 0.3 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 8 | 0.7 | 4.3 | 20 | 1.8 | 10.9 | 1.6 | 10.0 |
| 2-METHYL-1-BUTENE | 5 | 0.4 | 2.0 | 7 | 0.6 | 2.9 | 0.6 | 2.7 |
| PENTANE | 6 | 0.5 | 0.6 | 3 | 0.3 | 0.3 | 0.3 | 0.3 |
| UNIDENTIFIED C5 OLEFINS | 10 | 0.8 | 7.3 | 0 | 0.0 | 0.0 | 0.1 | 1.0 |
| 2-METHYL-1,3-BUTADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-PENTENE | 3 | 0.2 | 2.1 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 3,3-DIMETHYL-1-BUTENE | 4 | 0.6 | 2.0 | 0 | 0.4 | 0.0 | 0.0 | 0.0 |
| CIS-2-PENTENE | 4 | 0.0 | 2.0 | 0 | 0.9 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.9 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTADIENE | 8 | 0.7 | 5.2 | [illegible] | 0.9 | [illegible].3 | 0.0 | 2.7 |
| 2,2-DIMETHYLBUTANE | 3 | 0.2 | 2.[illegible] | [illegible] | 0.2 | 0.2 | 0.2 | 0.[illegible] |
| CYCLOPENTENE | 4 | 0.3 | 2.[illegible] | 0 | 0.4 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-1-PENTENE | 4 | 0.0 | 0.0 | 0 | 0.4 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.4 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTANE | 4 | 0.0 | 2.0 | 0 | 0.4 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLBUTANE | [illegible] | 0.3 | 0.[illegible] | 0 | 0.9 | 0.0 | 0.0 | 0.0 |
| MTBE | 4 | 0.0 | 0.0 | 0 | 0.4 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-1-BUTENE | 4 | 0.0 | 2.0 | 0 | 0.4 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.4 | 0.0 | 0.0 | 0.0 |
| 2-METHYLPENTANE | [illegible] | 0.[illegible] | 0.[illegible] | [illegible] | 0.4 | 0.2 | 0.2 | 0.[illegible] |
| 4-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 2.0 | 0 | 0.4 | 0.0 | 0.0 | 0.0 |
| 3-METHYLPENTANE | 4 | 0.4 | 2.8 | [illegible] | 0.4 | 0.2 | 0.2 | 0.3 |
| 2-METHYL-1-PENTENE | 7 | 0.6 | 2.8 | 0 | 0.4 | [illegible].6 | 0.0 | [illegible].8 |
| 1-HEXENE | 7 | 0.6 | 2.8 | 0 | 0.4 | [illegible].6 | 0.0 | [illegible].8 |
| HEXANE | 1 | 0.4 | 0.1 | 0 | 0.4 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C6 OLEFINS | 19 | [illegible].7 | 11.2 | 10 | 0.9 | [illegible].8 | [illegible].0 | 0.[illegible] |
| TRANS-3-HEXENE | 4 | 0.4 | 2.0 | 0 | 0.4 | 0.0 | 0.0 | 0.0 |
| CIS-3-HEXENE | 4 | 0.6 | 2.0 | 0 | 0.4 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 4 | 0.4 | 0.5 | 4 | 0.4 | 0.5 | 0.4 | 0.5 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 4 | 0.3 | 1.8 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| BENZENE | 69 | 6.0 | 2.5 | 38 | 3.3 | 1.4 | 3.7 | 1.6 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLPENTANE | 1 | 0.[illegible] | 0.[illegible] | [illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLPENTANE | 40 | 3.5 | [illegible] | 8 | 0.7 | 0.6 | 1.1 | [illegible].0 |
| 2-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-3-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C7 | [illegible] | 0.[illegible] | 2.2 | [illegible] | 0.[illegible] | [illegible] | 0.[illegible] | 1.4 |
| 2-METHYL-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | [illegible].0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOLUENE | 47 | 4.1 | 11.3 | 34 | [illegible] | 8.0 | 3.1 | 8.[illegible] |
| 2,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4,4-TETRAMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 7 | 0.7 | 1.3 | 3 | 0.3 | 0.6 | 0.4 | 0.7 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-OCTENE | [illegible] | 0.4 | [illegible].0 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.1 |
| TRANS-4-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C8 | 7 | 0.6 | [illegible].0 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.[illegible] |
| TRANS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-ETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLBENZENE | [illegible] | 0.[illegible] | 0.6 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 2,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| m-& p-XYLENE | [illegible] | 0.[illegible] | 2.2 | [illegible] | 0.[illegible] | [illegible].[illegible] | 0.[illegible] | 2.2 |
| 4-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLOCTANE | [illegible] | 0.[illegible] | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| STYRENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| o-XYLENE | [illegible] | 0.[illegible] | [illegible].0 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-NONENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NONANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| n-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3,5-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DECANE | 1 | 0.[illegible] | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ISOBUTYLBENZENE | 1 | 0.[illegible] | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S-BUTYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| COMPOUND | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| [illegible]DECANE | 0 | 0.[illegible] | 0.1 | [illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.4 |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 11 | 1.0 | 8.7 | 29 | [illegible].5 | 22.6 | 2.3 | 20.6 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENT-BENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.4 |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| DODECANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| UNIDENTIFIED C9-C12+ | 0 | 0.[illegible] | 1.3 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.[illegible] |
| FORMALDEHYDE | 417 | 36.5 | 260.6 | 247 | 21.6 | 154.2 | 23.7 | 169.4 |
| ACETALDEHYDE | 157 | 13.7 | 75.8 | 90 | 7.9 | 43.5 | 8.7 | 48.1 |
| ACROLEIN | 29 | 2.6 | 17.4 | 12 | 1.1 | 7.3 | 1.3 | 8.7 |
| ACETONE | 7 | 0.7 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.[illegible] |
| PROPIONALDEHYDE | 26 | 2.2 | 14.6 | 14 | 1.2 | 7.8 | 1.3 | 8.8 |
| CROTONALDEHYDE | 45 | 3.9 | 21.1 | 25 | 2.1 | 11.6 | 2.4 | 13.0 |
| ISOBUTYRALDEHYDE | 12 | 1.0 | [illegible].4 | 6 | 0.5 | [illegible].5 | 0.6 | [illegible].0 |
| METHYL ETHYL KETONE | 12 | 1.0 | [illegible] | 6 | 0.[illegible] | 0.5 | 0.6 | 0.7 |
| BENZALDEHYDE | 7 | 0.6 | -0.3 | 0 | 0.0 | 0.[illegible] | 0.4 | 0.[illegible] |
| HEXANALDEHYDE | 20 | 1.8 | 6.6 | 11 | 1.0 | 3.7 | 1.1 | 4.1 |
| | | | | | | | | |
| SUMMED SPECIATED VALUES | 1902 | 166 | 967 | 1074 | 94 | 567 | 104.1 | 624.1 |

TEST FUEL: RME, NO CATALYST
ENGINE: 1995 CUMMINS
TEST DATE: 11/14/95
TEST FUEL: EM-2126-F

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 6 | 0.5 | 0.1 | 0 | 0.0 | 0.0 | 0.1 | 0.0 |
| ETHYLENE | 410 | 34.6 | 252.3 | 245 | 20.8 | 151.3 | 22.7 | 165.8 |
| PROPANE | 0 | 0.0 | 0.0 | 53 | 4.5 | 2.2 | 3.8 | 1.8 |
| PROPYLENE | 72 | 6.0 | 56.8 | 43 | 3.7 | 34.4 | 4.0 | 37.6 |
| ACETYLENE | 128 | 10.8 | 5.4 | 75 | 6.3 | 3.2 | 7.0 | 3.5 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 0 | 0.0 | 0.0 | 6 | 0.5 | 0.5 | 0.4 | 0.4 |
| TRANS-2-BUTENE | 2 | 0.2 | 1.6 | 2 | 0.2 | 2.0 | 0.2 | 2.0 |
| 1-BUTENE | 27 | 2.3 | 20.4 | 16 | 1.4 | 12.3 | 1.5 | 13.4 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 7 | 0.6 | 3.1 | 6 | 0.5 | 2.6 | 0.5 | 2.7 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 5 | 0.4 | 0.1 | 0 | 0.0 | 0.0 | 0.1 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 38 | 3.2 | 35.2 | 0 | 0.0 | 0.0 | 0.5 | 5.0 |
| 2-METHYLPROPANE (ISOBUTANE) | 0 | 0.0 | 0.0 | 2 | 0.2 | 0.2 | 0.1 | 0.2 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 3 | 0.2 | 0.3 | 18 | 1.6 | 2.2 | 1.4 | 1.9 |
| 2-BUTYNE | 3 | 0.2 | 2.2 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 1-PENTENE | 3 | 0.0 | [illegible] | 29 | 2.4 | 15.2 | [illegible] | 13.4 |
| 2-METHYL-1-BUTENE | 3 | 0.3 | 1.6 | 0 | 0.0 | 0.0 | 0.0 | [illegible] |
| PENTANE | 7 | 0.6 | 0.6 | 8 | 0.7 | 0.7 | 0.7 | 0.7 |
| UNIDENTIFIED C5 OLEFINS | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-1,3-BUTADIENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-PENTENE | 3 | [illegible] | 2.2 | 0 | 0.0 | 0.0 | 0.0 | [illegible] |
| 3,3-DIMETHYL-1-BUTENE | 5 | [illegible] | 1.6 | [illegible] | 0.0 | [illegible] | 0.0 | 1.9 |
| CIS-2-PENTENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-BUTENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTADIENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLBUTANE | 3 | 0.3 | [illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTENE | 3 | [illegible] | [illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 4-METHYL-1-PENTENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-1-PENTENE | 3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTANE | 3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLBUTANE | 3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MTBE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-1-BUTENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-CIS-2-PENTENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLPENTANE | 5 | 0.0 | 0.7 | 0 | [illegible] | [illegible] | 0.3 | 2.5 |
| 4-METHYL-TRANS-2-PENTENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLPENTANE | 5 | 0.4 | 2.5 | 0 | 0.0 | 0.0 | [illegible] | [illegible] |
| 2-METHYL-1-PENTENE | 7 | 0.6 | 2.5 | 0 | [illegible] | [illegible] | 0.0 | 1.6 |
| 1-HEXENE | 7 | 0.6 | 2.5 | 0 | [illegible] | [illegible] | 0.0 | 1.6 |
| HEXANE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | [illegible] | [illegible] |
| UNIDENTIFIED C6 OLEFINS | 5 | 0.4 | 0.8 | 0 | 0.0 | 0.0 | 0.0 | [illegible] |
| TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-3-HEXENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEXENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 17 | 1.4 | 9.4 | 0 | 0.0 | 0.0 | 0.2 | 1.3 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 3 | 0.2 | 0.3 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 5 | 0.4 | 2.2 | 0 | 0.0 | 0.0 | 0.1 | 0.3 |
| BENZENE | 60 | 5.0 | 2.1 | 31 | 2.7 | 1.1 | 3.0 | 1.3 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLPENTANE | [illegible] | 0.[illegible] | 1.5 | [illegible] | 0.2 | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.0 | 0 | 0.2 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.2 | 0.0 | 0.0 | 0.0 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.2 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLPENTANE | 9 | 0.8 | 0.7 | 7 | 0.6 | 0.6 | 0.6 | 1.5 |
| 2-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-3-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C7 | [illegible] | 0.[illegible] | 1.5 | 9 | 0.8 | 3.5 | 0.7 | [illegible].2 |
| 2-METHYL-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | [illegible] | 0.[illegible] | [illegible].9 | [illegible] | 0.2 | 1.5 | 0.3 | 1.5 |
| 2,4,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 1.5 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYLPENTANE | 3 | 0.[illegible] | 0.3 | [illegible] | 0.2 | 0.[illegible] | 0.2 | 0.[illegible] |
| TOLUENE | 133 | 11.2 | 30.6 | 24 | [illegible].0 | [illegible].6 | [illegible].2 | 9.1 |
| 2,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4,4-TETRAMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP–HR | OZONE, MG/BHP–HR | MG | MG/BHP–HR | OZONE, MG/BHP–HR | MG/BHP–HR | OZONE, MG/BHP–HR |
| CIS–1,3–DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS–1,4–DIMETHYLCYCLOHEXANE | 6 | 0.5 | 1.0 | 0 | 0.0 | 0.0 | 0.1 | 0.1 |
| 3–ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5–TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS–1–METHYL–3–ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1–DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS–1–METHYL–2–ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–METHYL–1–ETHYL–CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4–TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4–TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS–1,2–DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–OCTENE | [illegible] | 0.3 | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| TRANS–4–OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C8 | 0 | 0.0 | 1.2 | 0 | 0.0 | 0.0 | 0.1 | 0.[illegible] |
| TRANS–2–OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS–1,3–DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS–1,4–DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS–2–OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,5–TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS–1–METHYL–2–ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2–METHYL–2–ETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4–DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4,4–DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS–1,2–DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2–METHYL–4–ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6–DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3–TRIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6–DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3–DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,5–DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3–DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| m–& p–XYLENE | 0 | 0.0 | 0.0 | 3 | 0.2 | 1.7 | 0.2 | 1.5 |
| 4–METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2–METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3–METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| STYRENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| o–XYLENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,6–TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–NONENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NONANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2–DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4–DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| n–PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–METHYL–3–ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–METHYL–4–ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3,5–TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–METHYL–2–ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4–TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DECANE | 1 | 0.[illegible] | 0.[illegible] | [illegible] | 0.[illegible] | 0.1 | 0.2 | 0.[illegible] |
| ISOBUTYLBENZENE | 1 | 0.[illegible] | 0.2 | [illegible] | 0.[illegible] | 0.1 | 0.2 | 0.[illegible] |
| METHYLPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S–BUTYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–METHYL–3–ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3–TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–METHYL–4–ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 8 | 0.7 | 5.9 | 0.6 | 5.1 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| [illegible]DECANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 25 | 2.1 | 19.1 | 14 | [illegible] | 10.7 | 1.3 | 11.9 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.5 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENT-BENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DODECANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C9-C12+ | 7 | 0.6 | 2.3 | [illegible] | 0.3 | [illegible] | [illegible] | 1.2 |
| FORMALDEHYDE | 340 | 28.7 | 205.3 | 220 | 18.6 | 132.9 | 20.0 | 143.3 |
| ACETALDEHYDE | 104 | 8.8 | 48.3 | 68 | [illegible] | 32.0 | [illegible] | 34.3 |
| ACROLEIN | 19 | [illegible] | 10.7 | 19 | 1.6 | 11.0 | 1.6 | 11.9 |
| ACETONE | 23 | [illegible] | 1.1 | 39 | [illegible] | [illegible] | 3.1 | 1.7 |
| PROPIONALDEHYDE | 27 | 2.3 | 15.0 | 22 | 1.3 | 12.4 | [illegible] | 12.8 |
| CROTONALDEHYDE | 25 | 2.1 | 11.3 | 14 | 1.2 | [illegible] | 1.3 | 7.2 |
| ISOBUTYRALDEHYDE | 19 | 0.9 | [illegible] | 6 | [illegible] | 2.5 | 0.5 | [illegible] |
| METHYL ETHYL KETONE | 19 | 0.9 | [illegible] | 6 | 0.5 | 0.6 | [illegible] | 0.6 |
| BENZALDEHYDE | 6 | [illegible] | 40.3 | 0 | 0.4 | -0.2 | 0.0 | -0.2 |
| HEXANALDEHYDE | 11 | 0.9 | 3.5 | 4 | 0.3 | 1.2 | 0.4 | 1.6 |
|  |  |  |  |  |  |  |  |  |
| SUMMED SPECIATED VALUES | 1622 | 137 | 770 | 1035 | 88 | 466 | 94.7 | 509.0 |

TEST FUEL: RME, WITH CATALYST
ENGINE: 1995 CUMMINS
TEST DATE: 11/15/95
TEST FUEL: EM-2130-F

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 6 | 0.5 | 0.1 | 3 | 0.3 | 0.1 | 0.3 | 0.1 |
| ETHYLENE | 353 | 29.7 | 216.8 | 214 | 18.0 | 131.4 | 19.7 | 143.6 |
| PROPANE | 0 | 0.0 | 0.0 | 21 | 1.8 | 0.9 | 1.5 | 0.7 |
| PROPYLENE | 56 | 4.7 | 44.2 | 33 | 2.8 | 26.1 | 3.1 | 28.7 |
| ACETYLENE | 92 | 7.7 | 3.9 | 42 | 3.5 | 1.8 | 4.1 | 2.1 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 0 | 0.0 | 0.0 | 25 | 2.1 | 2.2 | 1.8 | 1.8 |
| TRANS-2-BUTENE | 3 | 0.2 | 2.3 | 3 | 0.2 | 2.1 | 0.2 | 2.1 |
| 1-BUTENE | 20 | 1.7 | 15.2 | 11 | 0.9 | 8.3 | 1.0 | 9.3 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 5 | 0.4 | 2.4 | 5 | 0.4 | 2.1 | 0.4 | 2.1 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 28 | 2.4 | 25.6 | 13 | 1.1 | 12.3 | 1.3 | 14.2 |
| 2-METHYLPROPANE (ISOBUTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 6 | 0.5 | 0.7 | 13 | 1.1 | 1.5 | 1.0 | 1.4 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 14 | 1.2 | 7.4 | 11 | 0.9 | 5.8 | 1.0 | 6.0 |
| 2-METHYL-1-BUTENE | 8 | 0.6 | 3.1 | 0 | 0.0 | 0.0 | 0.1 | 0.4 |
| PENTANE | 8 | 0.7 | 0.7 | 8 | 0.7 | 0.7 | 0.7 | 0.7 |
| UNIDENTIFIED C5 OLEFINS | 4 | 0.3 | 2.9 | 0 | 0.0 | 0.0 | 0.0 | 0.4 |
| 2-METHYL-1,3-BUTADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTADIENE | [illegible] | 0.3 | [illegible] | 0 | 0.0 | 0.0 | 0.0 | [illegible] |
| 2,2-DIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MTBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLPENTANE | [illegible] | [illegible] | [illegible] | 3 | [illegible] | 0.0 | [illegible] | 0.0 |
| 4-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLPENTANE | 1 | [illegible] | [illegible] | 3 | [illegible] | [illegible] | 0.2 | [illegible] |
| 2-METHYL-1-PENTENE | [illegible] | 0.0 | [illegible] | [illegible] | [illegible] | 0.8 | 0.2 | [illegible] |
| 1-HEXENE | [illegible] | 0.0 | [illegible] | 3 | [illegible] | 0.8 | 0.2 | [illegible] |
| HEXANE | 11 | 0.9 | 0.9 | 0 | 0.0 | 0.0 | [illegible] | [illegible] |
| UNIDENTIFIED C6 OLEFINS | 10 | 0.8 | 5.4 | 6 | 0.5 | 3.7 | 0.6 | 3.9 |
| TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 10 | 0.8 | 5.5 | 6 | 0.5 | 3.2 | 0.5 | 3.6 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 5 | 0.4 | 0.6 | 4 | 0.3 | 0.4 | 0.3 | 0.5 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 8 | 0.6 | 0.8 | 0 | 0.0 | 0.0 | 0.1 | 0.1 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BENZENE | 52 | 4.4 | 1.8 | 31 | 2.6 | 1.1 | 2.9 | 1.2 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLPENTANE | 4 | 0.[illegible] | 0.[illegible] | [illegible] | 0.4 | 0.6 | 0.4 | 0.6 |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLPENTANE | 10 | 0.8 | 0.[illegible] | 6 | 0.[illegible] | 0.[illegible] | 0.6 | 0.[illegible] |
| 2-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-3-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C7 | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-1-PENTENE | [illegible] | 0.[illegible] | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | [illegible].0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | [illegible] | 0.[illegible] | 0.[illegible] | 0.2 | 0.[illegible] |
| TOLUENE | 32 | 2.7 | 7.4 | 9 | 0.7 | [illegible].0 | [illegible].0 | [illegible].8 |
| 2,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4,4-TETRAMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.3 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 1-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| TRANS-4-OCTENE | 0 | 0.0 | 0.3 | 0 | 0.3 | 0.0 | 0.0 | 0.3 |
| OCTANE | 0 | 0.0 | 0.3 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| UNIDENTIFIED C8 | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-OCTENE | 0 | 0.0 | 0.3 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.3 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| 2,3,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.3 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-ETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| 4,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.3 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOHEXANE | 0 | 0.0 | 0.3 | 0 | 0.3 | 0.0 | 0.0 | 0.3 |
| PROPYLCYCLOHEXANE | 0 | 0.0 | 0.3 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.0 | 0.3 | 0 | 0.3 | 0.0 | 0.0 | 0.3 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| m-& p-XYLENE | 4 | 0.0 | [illegible].3 | 0 | 0.3 | [illegible].3 | 0.3 | 2.4 |
| 4-METHYLOCTANE | 0 | 0.0 | 0.3 | 0 | 0.3 | 0.0 | 0.0 | 0.3 |
| 2-METHYLOCTANE | 0 | 0.0 | 0.3 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| 3-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| STYRENE | 0 | 0.0 | 0.3 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| o-XYLENE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.3 |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-NONENE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.3 |
| NONANE | 0 | 0.0 | 0.3 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 2,4-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| n-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 1-METHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 1-METHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 1,3,5-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 1-METHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| DECANE | 2 | 0.[illegible] | 0.1 | 2 | 0.3 | 0.1 | 0.2 | 0.3 |
| ISOBUTYLBENZENE | [illegible] | 0.[illegible] | 0.3 | 2 | 0.[illegible] | 0.3 | 0.2 | 0.3 |
| METHYLPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.3 | 0.0 | 0.3 |
| S-BUTYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 1-METHYL-3-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 4 | 0.3 | 3.0 | 0.3 | 2.6 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNDECANE | 0 | 0.0 | 0.5 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.5 | 0.0 | 0.0 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.5 | 41 | 3.5 | 31.4 | [illegible] | 26.9 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.5 | 0 | 0.5 | 0.0 | 0.0 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.5 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.5 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.5 | 0.0 | 0.0 | 0.0 |
| N-PENT-BENZENE | 0 | 0.0 | 0.5 | 0 | 0.5 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | 0 | 0.0 | 0.5 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DODECANE | 0 | 0.0 | 0.0 | 0 | 0.5 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C9-C12+ | 7 | 0.6 | 2.2 | 1 | [illegible] | [illegible] | [illegible] | 0.5 |
| FORMALDEHYDE | 397 | 33.4 | 238.9 | 274 | 23.2 | 165.6 | 24.6 | 176.0 |
| ACETALDEHYDE | 174 | 14.7 | 81.0 | 123 | 10.3 | 57.1 | 11.0 | 60.5 |
| ACROLEIN | 19 | 1.6 | 10.8 | 10 | 0.5 | 5.5 | 0.5 | [illegible] |
| ACETONE | 16 | 1.4 | 0.5 | 22 | 1.9 | 1.0 | 1.8 | 1.0 |
| PROPIONALDEHYDE | 17 | 1.6 | 3.5 | 8 | [illegible] | [illegible] | 0.8 | 5.2 |
| CROTONALDEHYDE | 19 | 1.4 | 6.5 | 7 | 0.5 | [illegible] | 0.6 | 3.4 |
| ISOBUTYRALDEHYDE | 7 | 0.6 | 3.2 | 5 | 0.5 | 2.4 | 0.5 | 2.5 |
| METHYL ETHYL KETONE | 7 | 0.6 | 0.7 | [illegible] | 0.5 | 0.5 | 0.5 | 0.5 |
| BENZALDEHYDE | 0 | 0.0 | 0.5 | 5 | 0.5 | 0.0 | 0.5 | 0.0 |
| HEXANALDEHYDE | 17 | 1.4 | 5.3 | [illegible] | 0.5 | 1.0 | 0.5 | [illegible] |
|  |  |  |  |  |  |  |  |  |
| SUMMED SPECIATED VALUES | 1445 | 122 | 717 | 998 | 84 | 489 | 89.6 | 522.0 |

TEST FUEL: REE50, WITH CATALYST
ENGINE: 1995 CUMMINS
TEST DATE: 11/16/95
TEST FUEL: EM-2134-F

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 38 | 3.1 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| ETHANE | 6 | 0.5 | 0.1 | 0 | 0.0 | 0.0 | 0.1 | 0.0 |
| ETHYLENE | 366 | 30.4 | 221.4 | 197 | 16.3 | 118.7 | 18.3 | 133.4 |
| PROPANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLENE | 69 | 5.7 | 53.7 | 36 | 3.0 | 28.1 | 3.4 | 31.7 |
| ACETYLENE | 85 | 7.0 | 3.5 | 34 | 2.8 | 1.4 | 3.4 | 1.7 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-BUTENE | 4 | 0.3 | 3.1 | 3 | 0.2 | 2.3 | 0.2 | 2.4 |
| 1-BUTENE | 20 | 1.7 | 14.8 | 10 | 0.9 | 7.6 | 1.0 | 8.6 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 11 | 0.9 | 5.0 | 7 | 0.6 | 3.3 | 0.7 | 3.5 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 26 | 2.2 | 23.4 | 12 | 1.0 | 10.4 | 1.1 | 12.3 |
| 2-METHYLPROPANE (ISOBUTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 3 | 0.2 | 2.4 | 2 | 0.2 | 1.6 | 0.2 | 1.7 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 3 | 0.3 | 0.4 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 16 | 1.3 | 8.1 | 9 | 0.8 | 4.9 | 0.9 | 5.3 |
| 2-METHYL-1-BUTENE | 7 | 0.6 | 3.0 | 0 | 0.0 | 0.0 | 0.1 | 0.4 |
| PENTANE | 3 | 0.3 | 0.3 | 4 | 0.3 | 0.3 | 0.3 | 0.3 |
| UNIDENTIFIED C5 OLEFINS | 4 | 0.4 | 3.2 | 0 | 0.0 | 0.0 | 0.1 | 0.5 |
| 2-METHYL-1,3-BUTADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYL-1-BUTENE | 4 | 0.0 | 0.0 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-BUTENE | [illegible] | 0.[illegible] | 1.7 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| CYCLOPENTADIENE | 4 | 0.0 | 0.0 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLBUTANE | 4 | 0.0 | 0.0 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTENE | 4 | 0.0 | 0.0 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-1-PENTENE | 4 | 0.0 | 0.0 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTANE | 4 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLBUTANE | 0 | 0.0 | 0.0 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| MTBE | 0 | 0.0 | 0.0 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-1-BUTENE | 4 | 0.0 | 0.0 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-CIS-2-PENTENE | 4 | 0.0 | 0.0 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLPENTANE | 4 | 0.[illegible] | 0.4 | 3 | 0.[illegible] | 0.0 | 0.[illegible] | 0.0 |
| 4-METHYL-TRANS-2-PENTENE | 4 | 0.4 | 0.0 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLPENTANE | 4 | 0.4 | 0.[illegible] | 3 | 0.[illegible] | 0.0 | 0.3 | 0.4 |
| 2-METHYL-1-PENTENE | [illegible] | 0.4 | 1.7 | 3 | 0.[illegible] | [illegible].0 | 0.2 | 1.1 |
| 1-HEXENE | [illegible] | 0.4 | 1.7 | 3 | 0.[illegible] | [illegible].0 | 0.2 | 1.7 |
| HEXANE | 3 | 0.[illegible] | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C6 OLEFINS | 7 | 0.4 | [illegible] | 4 | 0.0 | [illegible] | 0.0 | [illegible] |
| TRANS-3-HEXENE | 4 | 0.4 | 0.0 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-3-HEXENE | 4 | 0.0 | 0.0 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEXENE | 0 | 0.0 | 0.0 | 4 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 3 | 0.2 | 0.3 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BENZENE | 53 | 4.4 | 1.9 | 27 | 2.2 | 0.9 | 2.5 | 1.1 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLPENTANE | 4 | 0.3 | 0.5 | 3 | 0.3 | 0.4 | 0.3 | 0.4 |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-3-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C7 | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOLUENE | 29 | 2.4 | 6.6 | 12 | 1.0 | 2.7 | 1.2 | 3.3 |
| 2,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4,4-TETRAMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 3 | 0.2 | 0.4 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-OCTENE | [illegible] | 0.[illegible] | 0.6 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| TRANS-4-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OCTANE | 0 | 0.[illegible] | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C8 | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-ETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLBENZENE | [illegible] | 0.[illegible] | 0.[illegible] | [illegible] | 0.[illegible] | 0.6 | 0.[illegible] | 0.6 |
| 2,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| m-& p-XYLENE | 0 | 0.[illegible] | 2.5 | 0 | 0.[illegible] | 2.4 | 0.[illegible] | 2.4 |
| 4-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| STYRENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| o-XYLENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-NONENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NONANE | [illegible] | 0.[illegible] | 0.[illegible] | 0 | 0.3 | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| n-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3,5-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4-TRIMETHYLBENZENE | 0 | 0.[illegible] | 2.7 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DECANE | [illegible] | 0.[illegible] | 0.[illegible] | 0 | 0.0 | 0.[illegible] | 0.0 | 0.[illegible] |
| ISOBUTYLBENZENE | [illegible] | 0.[illegible] | 0.[illegible] | 0 | 0.3 | 0.6 | 0.[illegible] | 0.6 |
| METHYLPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S-BUTYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNDECANE | [illegible] | 0.8 | 0.3 | [illegible] | 0.8 | [illegible] | 0.8 | [illegible] |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 24 | 2.0 | 18.3 | 17 | 1.4 | 13.0 | 1.5 | 13.7 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENT-BENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | 0 | 0.0 | 0.3 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DODECANE | [illegible] | [illegible] | 0.3 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| UNIDENTIFIED C9-C12+ | [illegible] | 0.3 | 1.1 | 17 | [illegible] | 5.4 | 1.2 | [illegible] |
| FORMALDEHYDE | 423 | 35.2 | 251.4 | 277 | 22.9 | 163.8 | 24.7 | 176.3 |
| ACETALDEHYDE | 230 | 19.1 | 105.4 | 156 | 12.9 | 71.2 | 13.8 | 76.1 |
| ACROLEIN | 27 | 2.2 | 16.0 | 12 | [illegible] | 6.9 | 1.8 | 8.0 |
| ACETONE | 34 | 2.9 | [illegible] | 20 | 1.6 | 0.9 | 1.8 | [illegible] |
| PROPIONALDEHYDE | 29 | 2.4 | 16.0 | 15 | 1.2 | 8.0 | 1.4 | 9.1 |
| CROTONALDEHYDE | 27 | 2.2 | 12.0 | 15 | [illegible] | [illegible] | [illegible] | 7.7 |
| ISOBUTYRALDEHYDE | 7 | 0.6 | 3.1 | [illegible] | [illegible] | 2.1 | [illegible] | [illegible] |
| METHYL ETHYL KETONE | 7 | 0.6 | 0.7 | [illegible] | 0.4 | [illegible] | [illegible] | [illegible] |
| BENZALDEHYDE | 8 | 0.7 | -0.4 | [illegible] | [illegible] | -0.2 | [illegible] | -0.2 |
| HEXANALDEHYDE | 4 | 0.3 | 1.3 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
|  |  |  |  |  |  |  |  |  |
| SUMMED SPECIATED VALUES | 1653 | 137 | 796 | 949 | 79 | 471 | 87.0 | 517.2 |

TEST FUEL: REE50, NO CATALYST
ENGINE: 1995 CUMMINS
TEST DATE: 11/17/95
TEST FUEL: EM-2134-F

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 3 | 0.2 | 0.0 | 34 | 2.8 | 0.0 | 2.5 | 0.0 |
| ETHANE | 5 | 0.4 | 0.1 | 4 | 0.3 | 0.1 | 0.3 | 0.1 |
| ETHYLENE | 426 | 34.7 | 253.1 | 276 | 22.7 | 165.5 | 24.4 | 178.1 |
| PROPANE | 0 | 0.0 | 0.0 | 12 | 1.0 | 0.5 | 0.9 | 0.4 |
| PROPYLENE | 85 | 6.9 | 65.1 | 55 | 4.6 | 42.8 | 4.9 | 46.0 |
| ACETYLENE | 119 | 9.7 | 4.8 | 72 | 5.9 | 2.9 | 6.4 | 3.2 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 6 | 0.5 | 0.5 | 0 | 0.0 | 0.0 | 0.1 | 0.1 |
| TRANS-2-BUTENE | 4 | 0.3 | 3.1 | 3 | 0.2 | 2.2 | 0.2 | 2.3 |
| 1-BUTENE | 27 | 2.2 | 20.0 | 18 | 1.5 | 13.3 | 1.6 | 14.2 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 14 | 1.2 | 6.1 | 10 | 0.8 | 4.4 | 0.9 | 4.6 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 35 | 2.9 | 31.1 | 21 | 1.7 | 18.8 | 1.9 | 20.5 |
| 2-METHYLPROPANE (ISOBUTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 3 | 0.2 | 0.3 | 3 | 0.3 | 0.4 | 0.3 | 0.4 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 10 | 0.8 | 4.9 | 10 | 0.8 | 5.1 | 0.8 | 5.1 |
| 2-METHYL-1-BUTENE | 7 | 0.6 | 2.9 | 6 | 0.5 | 2.3 | 0.5 | 2.4 |
| PENTANE | 8 | 0.6 | 0.7 | 8 | 0.7 | 0.7 | 0.7 | 0.7 |
| UNIDENTIFIED C5 OLEFINS | 4 | 0.3 | 3.0 | 4 | 0.4 | 3.1 | 0.4 | 3.1 |
| 2-METHYL-1,3-BUTADIENE | 1 | 0.1 | 0.7 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| TRANS-2-PENTENE | 3 | 0.2 | 1.9 | 3 | 0.2 | 2.0 | 0.2 | 2.0 |
| 3,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| 2-METHYL-2-BUTENE | 3 | 0.2 | [illegible] | 0 | 0.5 | 0.0 | 0.4 | 0.5 |
| CYCLOPENTADIENE | [illegible] | 0.0 | [illegible] | 0 | 0.0 | 0.0 | 0.4 | 0.5 |
| 2,2-DIMETHYLBUTANE | 4 | 0.2 | [illegible] | 6 | 0.5 | 0.0 | 0.4 | 0.0 |
| CYCLOPENTENE | [illegible] | 8.3 | [illegible] | 0 | 0.0 | 0.0 | 0.4 | 0.3 |
| 4-METHYL-1-PENTENE | [illegible] | 0.2 | [illegible] | 0 | 0.0 | 0.0 | 0.4 | [illegible] |
| 3-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| CYCLOPENTANE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| 2,3-DIMETHYLBUTANE | 6 | 0.5 | 0.6 | [illegible] | 0.5 | [illegible] | 0.3 | 0.3 |
| MTBE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| 2,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| 4-METHYL-CIS-2-PENTENE | 0 | 0.2 | 0.2 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| 2-METHYLPENTANE | 7 | 0.5 | 0.2 | [illegible] | 0.2 | [illegible] | 0.4 | 0.0 |
| 4-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| 3-METHYLPENTANE | 8 | 0.7 | [illegible] | 0 | 0.0 | 0.0 | 0.4 | [illegible] |
| 2-METHYL-1-PENTENE | 9 | 0.7 | 3.3 | 0 | 0.3 | 1.5 | 0.4 | [illegible] |
| 1-HEXENE | 9 | 0.7 | 3.3 | 0 | 0.3 | 1.5 | 0.4 | [illegible] |
| HEXANE | [illegible] | 0.2 | 0.2 | [illegible] | [illegible] | [illegible] | 0.4 | [illegible] |
| UNIDENTIFIED C6 OLEFINS | 21 | [illegible] | 11.3 | 0 | 0.0 | [illegible] | 0.3 | [illegible] |
| TRANS-3-HEXENE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| CIS-3-HEXENE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| TRANS-2-HEXENE | 0 | 0.2 | 0.2 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 3 | 0.2 | 0.4 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 6 | 0.5 | 0.7 | 4 | 0.3 | 0.4 | 0.3 | 0.4 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BENZENE | 51 | 4.2 | 1.8 | 34 | 2.8 | 1.2 | 3.0 | 1.3 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| CYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.2 | 0.0 | 0.0 |
| 2,3-DIMETHYLPENTANE | [illegible] | 0.2 | 0.[illegible] | 2 | 0.2 | 0.2 | 0.[illegible] | 0.[illegible] |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.0 | 3 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | [illegible] | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| CIS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLPENTANE | 17 | 1.4 | 1.3 | 11 | 0.9 | 0.2 | [illegible].2 | 0.9 |
| 2-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-3-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEPTANE | 0 | 0.0 | 0.0 | 3 | 0.[illegible] | 0.2 | 0.[illegible] | 0.[illegible] |
| UNIDENTIFIED C7 | 0 | 0.0 | 1.6 | 3 | 0.[illegible] | [illegible].2 | 0.[illegible] | 1.3 |
| 2-METHYL-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.2 | 0.2 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.2 | 0.2 | 0.0 |
| TRANS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.2 | 0.2 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.2 |
| 2,4,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.2 | 0.0 | 0.2 |
| 2,3-DIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.2 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.2 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.2 | 0.0 | 0.2 |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,3,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.2 | 0.0 | 0.2 |
| TOLUENE | 98 | 8.0 | 21.8 | 20 | 1.7 | 0.2 | [illegible].6 | 7.0 |
| 2,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,2,4,4-TETRAMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 4-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.2 | 0.2 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 5 | 0.4 | 0.8 | 4 | 0.3 | 0.7 | 0.4 | 0.7 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.2 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| 1-OCTENE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.0 | 0.1 | 0.[illegible] |
| TRANS-4-OCTENE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| OCTANE | 0 | 0.[illegible] | 0.[illegible] | [illegible] | 0.[illegible] | 0.2 | 0.[illegible] | 0.[illegible] |
| UNIDENTIFIED C8 | 0 | 0.3 | [illegible].0 | [illegible] | 0.[illegible] | 4.9 | 0.[illegible] | [illegible].0 |
| TRANS-2-OCTENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.0 | 0.8 | 0.0 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.2 | 0.0 | 0.0 |
| CIS-2-OCTENE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.0 |
| 2,3,5-TRIMETHYLHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.2 | 0.0 | 0.2 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.2 |
| 2-METHYL-2-ETHYLHEPTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.2 | 0.2 | 0.0 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 4,4-DIMETHYLHEPTANE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.2 | 0.0 | 0.0 |
| ETHYLCYCLOHEXANE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| PROPYLCYCLOHEXANE | 0 | 0.2 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.2 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.2 | 0.0 | 0 | 0.0 | 4.9 | 4.9 | 0.2 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.2 |
| 3,3-DIMETHYLHEPTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.2 | 0.2 | 0.2 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.2 |
| ETHYLBENZENE | 0 | 0.3 | 0.0 | [illegible] | 0.2 | 0.0 | 0.[illegible] | 0.7 |
| 2,3-DIMETHYLHEPTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.2 | 0.0 | 0.2 |
| m-& p-XYLENE | 8 | 0.7 | 0.0 | 8 | 0.7 | 4.9 | 0.7 | 4.9 |
| 4-METHYLOCTANE | 0 | 0.2 | 0.0 | 0 | 0.3 | 0.2 | 0.0 | 0.2 |
| 2-METHYLOCTANE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| 3-METHYLOCTANE | [illegible] | 0.3 | 0.[illegible] | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| STYRENE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| o-XYLENE | 5 | 0.3 | 2.5 | 0 | 0.[illegible] | 3.3 | 0.[illegible] | [illegible].2 |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.2 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.2 |
| 1-NONENE | [illegible] | 0.2 | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| NONANE | [illegible] | 0.3 | 0.[illegible] | [illegible] | 0.3 | 0.2 | 0.2 | 0.2 |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.2 | 0.0 | 0 | 0.3 | 0.0 | 0.2 | 0.2 |
| 2,2-DIMETHYLOCTANE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.2 | 0.2 | 0.2 |
| 2,4-DIMETHYLOCTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| n-PROPYLBENZENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 1-METHYL-3-ETHYLBENZENE | [illegible] | 0.2 | 1.7 | [illegible] | 0.3 | [illegible].0 | 0.[illegible] | [illegible].2 |
| 1-METHYL-4-ETHYLBENZENE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.2 |
| 1,3,5-TRIMETHYLBENZENE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.2 |
| 1-METHYL-2-ETHYLBENZENE | [illegible] | 0.2 | 1.7 | 0 | 0.0 | 0.2 | 0.0 | 0.2 |
| 1,2,4-TRIMETHYLBENZENE | 0 | 0.3 | 6.3 | [illegible] | 0.3 | 3.3 | 0.[illegible] | 0.2 |
| DECANE | 8 | 0.3 | 0.[illegible] | 0 | 0.3 | 0.[illegible] | 0.0 | 0.2 |
| ISOBUTYLBENZENE | [illegible] | 0.2 | 0.[illegible] | 0 | 0.3 | 0.0 | 0.[illegible] | 0.2 |
| METHYLPROPYLBENZENE | 0 | 0.2 | 0.0 | 0 | 0.3 | 0.2 | 0.2 | 0.2 |
| S-BUTYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 4.9 | 0.2 | 4.9 |
| 1-METHYL-3-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 3 | 0.2 | 1.2 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 3 | 0.2 | 1.6 | 0.2 | 1.3 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 3 | 0.2 | 1.9 | 0.2 | 1.6 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNDECANE | 17 | 0.9 | 0.7 | 10 | 0.9 | 0.0 | 0.9 | 0.0 |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 6 | 0.0 | 0.0 | 33 | 2.7 | 24.4 | 2.4 | 21.6 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENT-BENZENE | 0 | 0.0 | 0.6 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DODECANE | 8 | 0.6 | 0.0 | 9 | 0.8 | 0.3 | 0.8 | 3.3 |
| UNIDENTIFIED C9-C12+ | 17 | 1.4 | 5.3 | 9 | 0.7 | 0.8 | 0.8 | 3.2 |
| FORMALDEHYDE | 348 | 28.4 | 202.8 | 243 | 20.0 | 142.9 | 21.2 | 151.5 |
| ACETALDEHYDE | 124 | 10.1 | 55.9 | 88 | 7.2 | 40.0 | 7.7 | 42.2 |
| ACROLEIN | 21 | 0.7 | 11.7 | 17 | 0.0 | 9.2 | 0.0 | 9.6 |
| ACETONE | 12 | 0.9 | 0.0 | 12 | 0.0 | 0.6 | 0.0 | 0.6 |
| PROPIONALDEHYDE | 8 | 0.0 | 1.4 | 7 | 0.6 | 0.0 | 0.6 | 0.6 |
| CROTONALDEHYDE | 22 | 1.8 | 9.7 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ISOBUTYRALDEHYDE | 8 | 0.7 | 0.6 | 7 | 0.6 | 3.2 | 0.6 | 3.3 |
| METHYL ETHYL KETONE | 8 | 0.7 | 0.8 | 7 | 0.6 | 2.7 | 0.6 | 0.0 |
| BENZALDEHYDE | 7 | 0.6 | –0.3 | 0 | 0.3 | –0.2 | 0.0 | –0.2 |
| HEXANALDEHYDE | 9 | 0.7 | 2.6 | 0 | 0.0 | 0.0 | 0.1 | 0.4 |
|  |  |  |  |  |  |  |  |  |
| SUMMED SPECIATED VALUES | 1705 | 139 | 779 | 1141 | 94 | 526 | 100.2 | 562.4 |

TEST FUEL: RME50, NO CATALYST
ENGINE: 1995 CUMMINS
TEST DATE: 11/21/95
TEST FUEL: EM-2136-F

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 30 | 2.4 | 0.0 | 22 | 1.8 | 0.0 | 1.9 | 0.0 |
| ETHANE | 5 | 0.4 | 0.1 | 1 | 0.0 | 0.0 | 0.1 | 0.0 |
| ETHYLENE | 345 | 28.1 | 204.6 | 233 | 19.1 | 139.5 | 20.4 | 148.8 |
| PROPANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLENE | 75 | 6.1 | 57.2 | 52 | 4.2 | 39.9 | 4.5 | 42.3 |
| ACETYLENE | 106 | 8.6 | 4.3 | 68 | 5.6 | 2.8 | 6.0 | 3.0 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-BUTENE | 3 | 0.3 | 2.7 | 2 | 0.2 | 1.9 | 0.2 | 2.0 |
| 1-BUTENE | 25 | 2.0 | 18.0 | 16 | 1.3 | 12.0 | 1.4 | 12.9 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 13 | 1.0 | 5.4 | 10 | 0.8 | 4.2 | 0.8 | 4.4 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 32 | 2.6 | 28.2 | 21 | 1.7 | 19.0 | 1.9 | 20.3 |
| 2-METHYLPROPANE (ISOBUTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 2 | 0.2 | 1.9 | 2 | 0.2 | 1.7 | 0.2 | 1.7 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 4 | 0.3 | 1.9 | 9 | 0.8 | 4.9 | 0.7 | 4.4 |
| 2-METHYL-1-BUTENE | 5 | 0.4 | 2.0 | 3 | 0.2 | 1.1 | 0.3 | 1.2 |
| PENTANE | 2 | 0.2 | 0.2 | 1 | 0.1 | 0.1 | 0.1 | 0.1 |
| UNIDENTIFIED C5 OLEFINS | 14 | 1.1 | 9.8 | 12 | 1.0 | 8.5 | 1.0 | 8.7 |
| 2-METHYL-1,3-BUTADIENE | 3 | 0.3 | 2.4 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-BUTENE | [illegible] | 0.[illegible] | [illegible].6 | [illegible] | 0.[illegible] | 1.5 | 0.[illegible] | 1.5 |
| CYCLOPENTADIENE | 0 | 0.0 | 0.4 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLBUTANE | 7 | 0.[illegible] | 0.0 | 0 | 0.0 | 0.0 | 0.1 | 0.[illegible] |
| CYCLOPENTENE | [illegible] | 0.[illegible] | [illegible].4 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 4-METHYL-1-PENTENE | 0 | 0.0 | 0.4 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-1-PENTENE | 6 | 0.[illegible] | [illegible].4 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.[illegible] |
| CYCLOPENTANE | 0 | 0.0 | 0.4 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLBUTANE | 0 | 0.[illegible] | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MTBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.4 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.4 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLPENTANE | [illegible] | 0.[illegible] | 0.4 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 4-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.4 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLPENTANE | 2 | 0.2 | 0.4 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-1-PENTENE | 6 | 0.[illegible] | 2.1 | [illegible] | 0.3 | 1.2 | 0.[illegible] | 1.3 |
| 1-HEXENE | 6 | 0.[illegible] | 2.1 | [illegible] | 0.[illegible] | 1.2 | 0.1 | [illegible].[illegible] |
| HEXANE | [illegible] | 0.[illegible] | 0.2 | 1 | 0.1 | 0.[illegible] | 0.1 | 0.1 |
| UNIDENTIFIED C6 OLEFINS | 15 | [illegible].[illegible] | 7.9 | 7 | 0.6 | [illegible].0 | 0.[illegible] | 1.5 |
| TRANS-3-HEXENE | 0 | 0.0 | 0.4 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 10 | 0.8 | 5.6 | 6 | 0.5 | 3.1 | 0.5 | 3.5 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 19 | 1.6 | 8.8 | 9 | 0.7 | 4.1 | 0.8 | 4.8 |
| BENZENE | 50 | 4.0 | 1.7 | 32 | 2.6 | 1.1 | 2.8 | 1.2 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLPENTANE | 4 | 0.[illegible] | 0.[illegible] | 3 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,3-DIMETHYLCYCLOPENTANE | 4 | 0.[illegible] | 0.[illegible] | 3 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| 3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLPENTANE | 8 | 0.6 | 0.6 | 6 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| 2-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-3-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C7 | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | 3 | 0.[illegible] | 1.4 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 2,4,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYLPENTANE | 3 | 0.[illegible] | 0.[illegible] | 3 | 0.3 | 0.3 | 0.[illegible] | 0.[illegible] |
| TOLUENE | 33 | 2.7 | 7.3 | 21 | [illegible] | 4.7 | [illegible] | 5.1 |
| 2,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4,4-TETRAMETHYLPENTANE | 4 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 5 | 0.4 | 0.7 | 3 | 0.2 | 0.4 | 0.2 | 0.5 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.4 | 0.2 | 0 | 0.0 | 0.0 | 0.6 | 0.0 |
| 1-OCTENE | 0 | 0.3 | 0.9 | 0 | 0.0 | 0.0 | 0.6 | [illegible] |
| TRANS-4-OCTENE | 0 | 0.4 | 0.2 | 0 | 0.0 | 0.0 | 0.6 | 0.0 |
| OCTANE | 8 | 0.2 | 0.4 | 3 | [illegible] | [illegible] | [illegible] | [illegible] |
| UNIDENTIFIED C8 | [illegible] | 0.4 | [illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-OCTENE | 0 | 0.0 | 0.2 | 0 | 0.0 | 0.0 | 0.6 | 0.6 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.4 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.2 | 0 | 0.0 | 0.0 | 0.6 | 0.0 |
| CIS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.4 | 0.0 | 0 | 0.0 | 0.0 | 0.6 | 0.0 |
| 2-METHYL-2-ETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.4 | 0.2 | 0 | 0.0 | 0.0 | 0.6 | 0.0 |
| 4,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.6 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | 8 | 0.2 | 0.2 | 8 | [illegible] | [illegible] | [illegible] | 0.5 |
| ETHYLCYCLOHEXANE | 0 | 0.0 | 0.2 | 0 | 0.0 | 0.0 | 0.6 | 0.0 |
| PROPYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.6 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.4 | 0.0 | 0.6 | 0.6 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.4 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.6 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.6 | 0.0 |
| 3,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.6 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.4 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.6 |
| ETHYLBENZENE | 0 | 0.3 | 0.2 | 3 | 0.2 | 0.6 | 0.6 | [illegible] |
| 2,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| m-& p-XYLENE | 8 | 0.4 | 5.6 | 7 | 0.6 | 0.0 | 0.6 | 0.6 |
| 4-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.6 | 0.6 |
| 2-METHYLOCTANE | 0 | 0.4 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| STYRENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.6 |
| o-XYLENE | 8 | 0.4 | 2.7 | 8 | [illegible] | 4.3 | 0.6 | 4.1 |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.6 |
| 1-NONENE | 8 | 0.2 | 0.2 | 3 | [illegible] | [illegible] | [illegible] | 0.6 |
| NONANE | 8 | 0.0 | 0.2 | 8 | [illegible] | 4.3 | 0.6 | [illegible] |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.4 | 0.0 | 0 | 0.0 | 0.0 | 0.6 | 0.6 |
| 2,2-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.6 |
| 2,4-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.6 |
| n-PROPYLBENZENE | 8 | 0.3 | 0.6 | 0 | 0.0 | 0.0 | 0.0 | 4.1 |
| 1-METHYL-3-ETHYLBENZENE | 8 | 0.4 | [illegible] | 8 | [illegible] | 2.1 | 0.6 | 2.2 |
| 1-METHYL-4-ETHYLBENZENE | 3 | 0.3 | [illegible] | 8 | 0.2 | [illegible] | [illegible] | 1.7 |
| 1,3,5-TRIMETHYLBENZENE | 8 | 0.3 | 2.7 | 8 | [illegible] | 2.1 | [illegible] | 2.2 |
| 1-METHYL-2-ETHYLBENZENE | 8 | 0.2 | 1.7 | 0 | 0.0 | 0.0 | 0.0 | [illegible] |
| 1,2,4-TRIMETHYLBENZENE | 11 | 0.9 | 7.8 | 7 | [illegible] | 0.8 | 0.6 | [illegible] |
| DECANE | 8 | 0.6 | 0.3 | 8 | 0.6 | [illegible] | 0.6 | 0.3 |
| ISOBUTYLBENZENE | 8 | 0.6 | 1.1 | 7 | 0.6 | 1.1 | 0.6 | 1.7 |
| METHYLPROPYLBENZENE | 0 | 0.4 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.6 |
| S-BUTYLBENZENE | 0 | 0.4 | 0.0 | 0 | 0.0 | 0.0 | 0.6 | 0.6 |
| 1-METHYL-3-ISOPROPYLBENZENE | 3 | 0.2 | 1.4 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 5 | 0.4 | 2.3 | 4 | 0.3 | 2.0 | 0.3 | 2.0 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 3 | 0.2 | 2.0 | 0.2 | 1.7 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 3 | 0.3 | 2.4 | 0.2 | 2.1 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNDECANE | 15 | 1.2 | 0.[illegible] | 12 | [illegible].0 | 0.0 | [illegible].0 | 0.0 |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | [illegible] | 0.[illegible] | [illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENT-BENZENE | [illegible] | 0.[illegible] | 0.0 | [illegible] | 0.4 | 0.7 | 0.0 | 0.6 |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNDECANE | 19 | 0.6 | 0.[illegible] | 14 | 0.9 | 0.[illegible] | 0.9 | 0.[illegible] |
| UNIDENTIFIED C9-C12+ | 26 | 2.1 | 6.[illegible] | 14 | 1.2 | 4.5 | 1.3 | [illegible].0 |
| FORMALDEHYDE | 331 | 26.9 | 192.4 | 225 | 18.5 | 132.1 | 19.7 | 140.7 |
| ACETALDEHYDE | 118 | 9.6 | 53.0 | 80 | 6.6 | 36.4 | 7.0 | 38.7 |
| ACROLEIN | 33 | [illegible] | 18.2 | 21 | [illegible] | 11.8 | 1.3 | 12.7 |
| ACETONE | 21 | [illegible] | [illegible].0 | 14 | 1.1 | 0.6 | 1.2 | 0.7 |
| PROPIONALDEHYDE | 21 | [illegible].9 | 12.5 | 14 | 1.5 | 9.[illegible] | 4.5 | 9.9 |
| CROTONALDEHYDE | 19 | 1.5 | 8.[illegible] | 16 | 1.1 | 7.3 | [illegible].0 | 7.5 |
| ISOBUTYRALDEHYDE | 12 | 0.9 | 0.9 | 9 | 0.4 | [illegible].8 | 0.8 | 0.0 |
| METHYL ETHYL KETONE | 12 | 0.9 | 1.1 | 9 | 0.[illegible] | 0.9 | 0.8 | 0.9 |
| BENZALDEHYDE | 19 | 1.5 | 0.9 | 16 | 1.2 | -0.7 | 1.3 | -0.7 |
| HEXANALDEHYDE | 19 | [illegible] | 4.7 | 37 | [illegible].0 | 11.4 | 2.8 | 10.5 |
|  |  |  |  |  |  |  |  |  |
| SUMMED SPECIATED VALUES | 1609 | 131 | 726 | 1115 | 92 | 507 | 97.3 | 538.6 |

TEST FUEL: RME50, WITH CATALYST
ENGINE: 1995 CUMMINS
TEST DATE: 11/22/95
TEST FUEL: EM-2136-F

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 9 | 0.8 | 0.0 | 71 | 5.8 | 0.1 | 5.1 | 0.1 |
| ETHANE | 5 | 0.4 | 0.1 | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| ETHYLENE | 312 | 25.5 | 185.9 | 197 | 16.2 | 117.9 | 17.5 | 127.6 |
| PROPANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLENE | 67 | 5.5 | 51.5 | 42 | 3.5 | 32.7 | 3.8 | 35.4 |
| ACETYLENE | 79 | 6.4 | 3.2 | 41 | 3.4 | 1.7 | 3.8 | 1.9 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-BUTENE | 4 | 0.3 | 3.0 | 3 | 0.2 | 2.3 | 0.2 | 2.4 |
| 1-BUTENE | 19 | 1.5 | 13.7 | 11 | 0.9 | 8.0 | 1.0 | 8.8 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 10 | 0.8 | 4.5 | 8 | 0.7 | 3.5 | 0.7 | 3.6 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 22 | 1.8 | 20.0 | 13 | 1.0 | 11.2 | 1.1 | 12.4 |
| 2-METHYLPROPANE (ISOBUTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 3 | 0.2 | 2.3 | 2 | 0.2 | 1.7 | 0.2 | 1.8 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 5 | 0.4 | 2.6 | 0 | 0.0 | 0.1 | 0.1 | 0.5 |
| 2-METHYL-1-BUTENE | 3 | 0.2 | 1.2 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| PENTANE | 2 | 0.2 | 0.2 | 0 | 0.0 | 0.0 | 0.1 | 0.1 |
| UNIDENTIFIED C5 OLEFINS | 13 | 1.1 | 9.5 | 11 | 0.9 | 8.3 | 1.0 | 8.4 |
| 2-METHYL-1,3-BUTADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-PENTENE | 3 | 0.2 | 2.0 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 3,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 2 | 0.0 | 0.0 | 0.2 | 0.2 |
| CIS-2-PENTENE | 0 | 0.0 | 0.0 | 2 | 0.0 | 0.0 | 0.2 | 0.2 |
| 2-METHYL-2-BUTENE | [illegible] | 0.3 | [illegible] | 2 | 0.0 | 0.0 | 0.2 | 0.2 |
| CYCLOPENTADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLBUTANE | 0 | 0.0 | 0.3 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTENE | 0 | 0.0 | 0.0 | 2 | 0.0 | 0.0 | 0.2 | 0.0 |
| 4-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 2 | 0.0 | 0.0 | 0.0 | 0.2 |
| 3-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 2 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTANE | 0 | 0.0 | 0.0 | 2 | 0.0 | 0.0 | 0.2 | 0.0 |
| 2,3-DIMETHYLBUTANE | 0 | 0.3 | 0.0 | 2 | 0.0 | 0.0 | 0.0 | [illegible] |
| MTBE | 0 | 0.3 | 0.3 | 2 | 0.0 | 0.0 | 0.2 | 0.0 |
| 2,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 2 | 0.0 | 0.0 | 0.2 | 0.2 |
| 4-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 2 | 0.0 | 0.0 | 0.2 | 0.2 |
| 2-METHYLPENTANE | [illegible] | 0.1 | [illegible] | 2 | 0.0 | 0.0 | 0.2 | 0.2 |
| 4-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 2 | 0.0 | 0.0 | 0.2 | 0.0 |
| 3-METHYLPENTANE | 0 | 0.0 | 0.0 | 1 | [illegible] | 0.1 | 0.1 | [illegible] |
| 2-METHYL-1-PENTENE | [illegible] | 0.3 | [illegible] | 2 | [illegible] | 0.8 | 0.2 | 0.2 |
| 1-HEXENE | [illegible] | 0.1 | [illegible] | 2 | [illegible] | 0.8 | 0.2 | 0.2 |
| HEXANE | 2 | 0.3 | [illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C6 OLEFINS | 7 | 0.6 | [illegible] | 2 | 0.0 | 0.0 | [illegible] | 0.6 |
| TRANS-3-HEXENE | 0 | 0.3 | 0.0 | 2 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-3-HEXENE | 0 | 0.0 | 0.0 | 2 | 0.0 | 0.0 | 0.2 | 0.0 |
| TRANS-2-HEXENE | 0 | 0.0 | 0.0 | 2 | 0.0 | 0.0 | 0.2 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 10 | 0.8 | 5.6 | 0 | 0.0 | 0.0 | 0.1 | 0.8 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 0 | 0.0 | 0.0 | 5 | 0.4 | 2.5 | 0.3 | 2.2 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 3 | 0.2 | 0.3 | 0.2 | 0.3 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BENZENE | 43 | 3.5 | 1.5 | 20 | 1.6 | 0.7 | 1.9 | 0.8 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXANE | 0 | 0.2 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLPENTANE | [illegible] | 0.2 | 0.0 | [illegible] | 0.[illegible] | 0.0 | 0.[illegible] | 0.0 |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,3-DIMETHYLCYCLOPENTANE | [illegible] | 0.2 | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 3-ETHYLPENTANE | 0 | 0.0 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLPENTANE | 6 | 0.[illegible] | 0.5 | 1 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.2 |
| 2-METHYL-1-HEXENE | 0 | 0.2 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-3-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C7 | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.[illegible] | 0.0 | 0.0 |
| 2-METHYL-2-HEXENE | 0 | 0.0 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.2 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLHEXANE | 0 | 0.2 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.2 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEXANE | 0 | 0.2 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYLPENTANE | [illegible] | 0.[illegible] | 0.3 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOLUENE | 84 | 6.2 | 18.7 | 14 | [illegible] | [illegible].0 | 1.9 | 5.3 |
| 2,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4,4-TETRAMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 3 | 0.3 | 0.5 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.5 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| 1-OCTENE | 0 | 0.5 | 0.8 | 0 | 0.3 | 0.0 | 0.3 | 0.[illegible] |
| TRANS-4-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.0 | 0.3 | 0.0 |
| OCTANE | [illegible] | 0.3 | 0.1 | 0 | 0.0 | 0.3 | 0.3 | 0.0 |
| UNIDENTIFIED C8 | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.3 | 0.0 | 0.0 |
| TRANS-2-OCTENE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.3 | 0.3 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.3 | 0.3 | 0.0 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| CIS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.3 | 0.3 | 0.0 |
| 2,3,5-TRIMETHYLHEXANE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.3 | 0.3 | 0.0 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-ETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | [illegible] | 0.2 | 0.[illegible] | 0 | 0.3 | 0.3 | 0.3 | 0.[illegible] |
| ETHYLCYCLOHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.3 | 0.3 | 0.0 |
| PROPYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.3 | 0.3 | 0.0 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.0 | 0.3 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.0 | 0.3 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.3 | 0.3 | 0.0 |
| 3,3-DIMETHYLHEPTANE | 0 | 0.3 | 0.0 | 0 | 0.3 | 0.3 | 0.3 | 0.0 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.3 | 0.0 | 0.0 |
| ETHYLBENZENE | [illegible] | 0.[illegible] | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 2,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| m-& p-XYLENE | 6 | 0.5 | 3.6 | 0 | 0.0 | 2.7 | 0.0 | [illegible].8 |
| 4-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| STYRENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| o-XYLENE | 0 | 0.3 | [illegible].[illegible] | 0 | 0.3 | 0.0 | 0.0 | 0.[illegible] |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.3 | 0.0 |
| 1-NONENE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.3 | 0.3 | 0.0 |
| NONANE | 0 | 0.3 | 0.[illegible] | 0 | 0.3 | 0.3 | 0.[illegible] | 0.[illegible] |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.3 | 0.3 | 0.0 |
| 2,2-DIMETHYLOCTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.3 | 0.3 | 0.0 |
| 2,4-DIMETHYLOCTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.3 | 0.3 | 0.0 |
| n-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.3 | 0.3 | 0.0 |
| 1-METHYL-3-ETHYLBENZENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.3 | 0.0 |
| 1-METHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.3 | 0.0 |
| 1,3,5-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.3 | 0.0 |
| 1-METHYL-2-ETHYLBENZENE | 0 | 0.5 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4-TRIMETHYLBENZENE | 0 | 0.5 | [illegible].8 | [illegible] | 0.[illegible] | [illegible].3 | 0.[illegible] | [illegible].[illegible] |
| DECANE | 6 | 0.5 | 0.[illegible] | 7 | 0.6 | 0.3 | 0.5 | 0.[illegible] |
| ISOBUTYLBENZENE | [illegible] | 0.2 | 0.[illegible] | [illegible] | 0.[illegible] | 0.[illegible] | 0.3 | 0.[illegible] |
| METHYLPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.3 | 0.0 |
| S-BUTYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.3 | 0.3 | 0.0 |
| 1-METHYL-3-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNDECANE | 9 | 0.[illegible] | 0.[illegible] | [illegible] | 0.8 | 0.[illegible] | 0.8 | 0.[illegible] |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 27 | [illegible].2 | 20.1 | [illegible].9 | 17.2 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENT-BENZENE | 0 | 0.0 | 0.0 | [illegible] | 0.2 | 0.9 | 0.[illegible] | 0.[illegible] |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNDECANE | 5 | 0.6 | 0.[illegible] | 6 | 0.[illegible] | 0.[illegible] | 0.6 | 0.[illegible] |
| UNIDENTIFIED C9-C12+ | 8 | 0.[illegible] | 2.5 | 7 | 0.6 | [illegible] | 0.6 | 2.2 |
| FORMALDEHYDE | 409 | 33.5 | 239.3 | 276 | 22.6 | 161.7 | 24.2 | 172.8 |
| ACETALDEHYDE | 184 | 15.0 | 83.0 | 127 | 10.4 | 57.4 | 11.1 | 61.1 |
| ACROLEIN | 30 | 2.4 | 16.6 | 18 | [illegible] | 12.6 | [illegible].6 | 11.0 |
| ACETONE | 3[illegible] | [illegible].9 | [illegible].6 | 25 | [illegible].0 | [illegible] | [illegible] | 1.2 |
| PROPIONALDEHYDE | 30 | [illegible] | 16.2 | 24 | [illegible].9 | 12.6 | [illegible].0 | 13.1 |
| CROTONALDEHYDE | 15 | 1.2 | 6.4 | 6 | 0.5 | 2.6 | 0.6 | 3.1 |
| ISOBUTYRALDEHYDE | 14 | 1.2 | 6.4 | 1 | 0.[illegible] | 2.6 | 0.3 | 1.4 |
| METHYL ETHYL KETONE | 14 | 1.2 | [illegible] | 1 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| BENZALDEHYDE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEXANALDEHYDE | 17 | 1.4 | 5.3 | 0 | 0.0 | 0.0 | 0.2 | 0.8 |
|  |  |  |  |  |  |  |  |  |
| SUMMED SPECIATED VALUES | 1547 | 127 | 728 | 1004 | 82 | 471 | 88.6 | 508.0 |

TEST FUEL: REE20, WITH CATALYST
ENGINE: 1995 CUMMINS
TEST DATE: 11/27/95
TEST FUEL: EM-2135-F

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 3 | 0.2 | 0.1 | 5 | 0.4 | 0.1 | 0.4 | 0.1 |
| ETHYLENE | 363 | 29.6 | 215.7 | 233 | 19.1 | 139.4 | 20.6 | 150.3 |
| PROPANE | 0 | 0.0 | 0.0 | 17 | 1.4 | 0.7 | 1.2 | 0.6 |
| PROPYLENE | 89 | 7.2 | 67.9 | 58 | 4.8 | 44.8 | 5.1 | 48.1 |
| ACETYLENE | 81 | 6.6 | 3.3 | 78 | 6.4 | 3.2 | 6.4 | 3.2 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-BUTENE | 5 | 0.4 | 4.1 | 4 | 0.3 | 3.1 | 0.3 | 3.3 |
| 1-BUTENE | 22 | 1.8 | 15.9 | 13 | 1.1 | 9.6 | 1.2 | 10.5 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 17 | 1.4 | 7.5 | 12 | 1.0 | 5.3 | 1.1 | 5.6 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 26 | 2.1 | 23.1 | 16 | 1.3 | 14.7 | 1.5 | 15.9 |
| 2-METHYLPROPANE (ISOBUTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 4 | 0.3 | 3.1 | 3 | 0.2 | 2.4 | 0.3 | 2.5 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 4 | 0.3 | 1.9 | 64 | 5.2 | 32.6 | 4.5 | 28.2 |
| 2-METHYL-1-BUTENE | 5 | 0.4 | 1.9 | 3 | 0.3 | 1.3 | 0.3 | 1.4 |
| PENTANE | 1 | 0.1 | 0.1 | 3 | 0.2 | 0.2 | 0.2 | 0.2 |
| UNIDENTIFIED C5 OLEFINS | 9 | 0.7 | 6.5 | 9 | 0.7 | 6.3 | 0.7 | 6.3 |
| 2-METHYL-1,3-BUTADIENE | 4 | 0.3 | 2.8 | 0 | 0.0 | 0.0 | 0.0 | 0.4 |
| TRANS-2-PENTENE | 3 | 0.3 | 2.4 | 3 | 0.2 | 2.1 | 0.2 | 2.2 |
| 3,3-DIMETHYL-1-BUTENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-PENTENE | 5 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-BUTENE | 0 | 0.3 | 0.0 | 3 | 0.0 | 0.0 | 0.2 | 1.6 |
| CYCLOPENTADIENE | 3 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.3 |
| 2,2-DIMETHYLBUTANE | 5 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-1-PENTENE | 5 | 0.0 | 1.1 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-1-PENTENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLBUTANE | 5 | 0.0 | 0.0 | 5 | 0.0 | 0.0 | 0.0 | 0.0 |
| MTBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-1-BUTENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-CIS-2-PENTENE | 5 | 0.0 | 0.0 | 5 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLPENTANE | 5 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | 0.1 | 0.1 |
| 4-METHYL-TRANS-2-PENTENE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLPENTANE | 5 | 0.0 | 0.0 | 5 | 0.0 | 0.0 | 0.1 | 0.1 |
| 2-METHYL-1-PENTENE | 1 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 1-HEXENE | 5 | 0.0 | 1.1 | 3 | 0.3 | 1.2 | 0.3 | 0.3 |
| HEXANE | 0 | 0.3 | 0.0 | 5 | 0.0 | 0.0 | 0.1 | 0.0 |
| UNIDENTIFIED C6 OLEFINS | 8 | 0.6 | 1.1 | 6 | 0.0 | 0.8 | 0.5 | 3.2 |
| TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 0 | 0.0 | 0.0 | 5 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETBE | 5 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 3 | 0.2 | 0.4 | 3 | 0.3 | 0.5 | 0.3 | 0.5 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 5 | 0.4 | 0.5 | 5 | 0.4 | 0.5 | 0.4 | 0.5 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BENZENE | 39 | 3.2 | 1.3 | 27 | 2.2 | 0.9 | 2.4 | 1.0 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.0 |
| CYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLPENTANE | 2 | [illegible] | 0.2 | [illegible] | 0.2 | 0.0 | 0.2 | [illegible] |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,3-DIMETHYLCYCLOPENTANE | [illegible] | [illegible] | [illegible] | 0 | 0.0 | 0.0 | 0.0 | [illegible] |
| 3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLPENTANE | 7 | [illegible] | 0.5 | 6 | [illegible] | 0.0 | [illegible] | 0.0 |
| 2-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| TRANS-3-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.0 |
| HEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C7 | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2-METHYL-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.2 |
| 2,2-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | [illegible] | 0.0 | 0.0 | 0.2 |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.2 |
| 2,4-DIMETHYLHEXANE | 0 | [illegible] | [illegible] | 0 | 0.0 | 0.0 | 0.0 | [illegible] |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | [illegible] | 0.2 | 0.0 |
| 3,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.2 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYLPENTANE | [illegible] | 0.2 | [illegible] | [illegible] | 0.2 | [illegible] | 0.2 | 0.2 |
| TOLUENE | 43 | [illegible] | [illegible] | 18 | [illegible] | [illegible] | 1.8 | 0.2 |
| 2,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.0 |
| 2-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.0 |
| 3,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.2 |
| 2,2,4,4-TETRAMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.0 |
| 4-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.2 | 0.2 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| 1-OCTENE | [illegible] | 0.[illegible] | 0.6 | 3 | 0.[illegible] | 0.8 | 0.[illegible] | 0.7 |
| TRANS-4-OCTENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.9 |
| OCTANE | 0 | 0.3 | 0.[illegible] | 0 | 0.[illegible] | 0.7 | 0.3 | 0.9 |
| UNIDENTIFIED C8 | 0 | 0.3 | [illegible].0 | 3 | 0.[illegible] | 0.9 | 0.3 | 0.9 |
| TRANS-2-OCTENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.9 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.9 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| CIS-2-OCTENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| 2,3,5-TRIMETHYLHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.9 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| 2-METHYL-2-ETHYLHEPTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.9 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.9 |
| 4,4-DIMETHYLHEPTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.3 | 0.6 | 3 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.9 |
| ETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.9 |
| PROPYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.9 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.9 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| 3,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.9 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| ETHYLBENZENE | 6 | 0.[illegible] | [illegible].[illegible] | 3 | 0.[illegible] | 0.7 | 0.[illegible] | 4.6 |
| 2,3-DIMETHYLHEPTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| m-& p-XYLENE | 10 | 0.8 | 5.7 | 7 | 0.6 | 0.0 | 0.6 | 4.6 |
| 4-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| 2-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| 3-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.9 |
| STYRENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| o-XYLENE | 0 | 0.3 | [illegible].3 | [illegible] | 0.[illegible] | [illegible].8 | 0.3 | 4.6 |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.9 |
| 1-NONENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| NONANE | 6 | 0.[illegible] | 0.3 | 6 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 4.6 |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| 2,2-DIMETHYLOCTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.5 |
| 2,4-DIMETHYLOCTANE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| n-PROPYLBENZENE | 0 | 0.3 | 0.0 | [illegible] | 0.[illegible] | 0.6 | 0.[illegible] | 4.6 |
| 1-METHYL-3-ETHYLBENZENE | 4 | 0.3 | 2.4 | 3 | 0.[illegible] | [illegible].0 | 0.[illegible] | 4.6 |
| 1-METHYL-4-ETHYLBENZENE | 0 | 0.3 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| 1,3,5-TRIMETHYLBENZENE | 0 | 0.3 | [illegible].[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.5 |
| 1-METHYL-2-ETHYLBENZENE | 3 | 0.3 | 1.9 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| 1,2,4-TRIMETHYLBENZENE | 11 | 0.3 | 7.7 | 7 | 0.[illegible] | 0.8 | 0.6 | 5.2 |
| DECANE | 7 | 0.6 | 0.[illegible] | 7 | 0.6 | 0.3 | 0.6 | 0.9 |
| ISOBUTYLBENZENE | 7 | 0.6 | 1.1 | 7 | 0.[illegible] | [illegible].0 | 0.[illegible] | 4.6 |
| METHYLPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| S-BUTYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |
| 1-METHYL-4-ISOPROPYLBENZENE | 3 | 0.2 | [illegible].[illegible] | [illegible] | 0.[illegible] | 1.5 | 0.[illegible] | [illegible].5 |
| INDAN | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 4.6 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 3 | 0.3 | 1.5 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 3 | 0.2 | 2.0 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNDECANE | 13 | [illegible] | 0.0 | 13 | [illegible] | 0.4 | [illegible] | 0.0 |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENT-BENZENE | [illegible] | 0.4 | 0.6 | 0 | [illegible] | [illegible] | [illegible] | 0.5 |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | [illegible] | [illegible] | 1.6 | 0 | 0.0 | 0.0 | 0.0 | [illegible] |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DODECANE | 11 | 0.9 | [illegible] | 14 | 0.9 | 0.9 | 0.9 | 0.3 |
| UNIDENTIFIED C9-C12+ | 25 | 2.1 | 7.9 | 14 | [illegible] | 1.2 | 1.2 | [illegible] |
| FORMALDEHYDE | 520 | 42.3 | 302.5 | 319 | 26.1 | 187.0 | 28.5 | 203.5 |
| ACETALDEHYDE | 239 | 19.4 | 107.2 | 153 | 12.6 | 69.4 | 13.6 | 74.8 |
| ACROLEIN | 52 | [illegible] | 28.8 | 28 | 2.3 | 15.7 | [illegible] | 17.6 |
| ACETONE | 59 | [illegible] | 2.7 | 36 | [illegible] | 1.7 | 3.2 | 1.7 |
| PROPIONALDEHYDE | 38 | 3.1 | 20.8 | 16 | 1.2 | 7.9 | 1.5 | 9.7 |
| CROTONALDEHYDE | 16 | [illegible] | 7.2 | 16 | [illegible] | 7.2 | [illegible] | 7.2 |
| ISOBUTYRALDEHYDE | 10 | 0.8 | [illegible] | [illegible] | [illegible] | 7.2 | 0.3 | 1.7 |
| METHYL ETHYL KETONE | 10 | 0.8 | [illegible] | 3 | 0.2 | [illegible] | [illegible] | 0.0 |
| BENZALDEHYDE | 38 | 2.7 | -1.5 | 8 | [illegible] | -0.3 | [illegible] | -0.5 |
| HEXANALDEHYDE | 62 | 5.0 | 19.0 | 0 | 0.0 | 0.0 | 0.7 | 2.7 |
|  |  |  |  |  |  |  |  |  |
| SUMMED SPECIATED VALUES | 1961 | 160 | 918 | 1293 | 106 | 595 | 113.8 | 641.1 |

TEST FUEL: REE20, NO CATALYST
ENGINE: 1995 CUMMINS
TEST DATE: 11/28/95
TEST FUEL: EM-2135-F

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANE | 5 | 0.4 | 0.1 | 3 | 0.3 | 0.1 | 0.3 | 0.1 |
| ETHYLENE | 468 | 38.1 | 277.8 | 303 | 24.8 | 180.6 | 26.7 | 194.5 |
| PROPANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLENE | 119 | 9.7 | 91.2 | 77 | 6.3 | 59.6 | 6.8 | 64.1 |
| ACETYLENE | 122 | 9.9 | 5.0 | 77 | 6.3 | 3.2 | 6.8 | 3.4 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-BUTENE | 5 | 0.4 | 3.8 | 3 | 0.3 | 2.7 | 0.3 | 2.9 |
| 1-BUTENE | 33 | 2.7 | 23.8 | 22 | 1.8 | 15.7 | 1.9 | 16.9 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 22 | 1.8 | 9.5 | 15 | 1.2 | 6.4 | 1.3 | 6.8 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 38 | 3.1 | 33.6 | 26 | 2.2 | 23.4 | 2.3 | 24.9 |
| 2-METHYLPROPANE (ISOBUTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 3 | 0.3 | 2.8 | 2 | 0.2 | 1.8 | 0.2 | 2.0 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 19 | 1.6 | 9.8 | 0 | 0.0 | 0.0 | 0.2 | 1.4 |
| 2-METHYL-1-BUTENE | 6 | 0.5 | 2.2 | 5 | 0.4 | 2.0 | 0.4 | 2.0 |
| PENTANE | 5 | 0.4 | 0.4 | 5 | 0.4 | 0.4 | 0.4 | 0.4 |
| UNIDENTIFIED C5 OLEFINS | 3 | 0.3 | 2.5 | 4 | 0.3 | 2.6 | 0.3 | 2.6 |
| 2-METHYL-1,3-BUTADIENE | 6 | 0.5 | 4.2 | 3 | 0.3 | 2.4 | 0.3 | 2.7 |
| TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTADIENE | 7 | 0.5 | 4.1 | 0 | 0.0 | 2.1 | 0.0 | 2.4 |
| 2,2-DIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTENE | 3 | 0.3 | 1.9 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-1-PENTENE | 0 | 0.0 | 1.7 | 0 | 0.0 | 1.9 | 0.3 | 0.0 |
| 3-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLBUTANE | 0 | 0.0 | 0.5 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MTBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLPENTANE | 6 | 0.5 | 1.7 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-1-PENTENE | 6 | 0.5 | 2.1 | 0 | 0.0 | 1.9 | 0.0 | 0.9 |
| 1-HEXENE | 6 | 0.5 | 0.0 | 0 | 0.0 | 1.9 | 0.0 | 1.9 |
| HEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.5 | 0.0 |
| UNIDENTIFIED C6 OLEFINS | 15 | 0.0 | 8.0 | 0 | 0.0 | 0.3 | 0.5 | 0.0 |
| TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

|  | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
| COMPOUND | MG | MG/BHP–HR | OZONE, MG/BHP–HR | MG | MG/BHP–HR | OZONE, MG/BHP–HR | MG/BHP–HR | OZONE, MG/BHP–HR |
| 3–METHYL–CIS–2–PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2–DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4–DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3–TRIMETHYL–1–BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3–TRIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4–DIMETHYL–1–PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BENZENE | 49 | 4.0 | 1.7 | 30 | 2.4 | 1.0 | 2.7 | 1.1 |
| 3–METHYL–1–HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3–DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2–METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3–DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1–DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3–METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS–1,3–DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3–ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS–1,2–DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS–1,3–DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4–TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2–METHYL–1–HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS–3–HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C7 | 0 | 0.0 | 1.9 | 3 | 0.0 | 1.0 | 0.3 | 1.2 |
| 2–METHYL–2–HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3–METHYL–TRANS–3–HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS–2–HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3–ETHYL–CIS–2–PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4–TRIMETHYL–1–PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4–TRIMETHYL–1–PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3–DIMETHYL–2–PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS–2–HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS–1,2–DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2–DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3–TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4–TRIMETHYL–2–PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3–TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5–DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4–DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–TRANS–2–CIS–4–TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3–DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–TRANS–2–CIS–3–TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,4–TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3–TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOLUENE | 25 | [illegible] | [illegible] | 15 | 1.2 | 3.3 | [illegible] | 3.6 |
| 2,3–DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,2–TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2–METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4–DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4,4–TETRAMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4–METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2–METHYL–3–ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6–DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3–METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1–CIS,2–TRANS,3–TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 5 | 0.4 | 0.9 | 3 | 0.3 | 0.5 | 0.3 | 0.5 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-OCTENE | 0 | 0.0 | [illegible].0 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.[illegible] |
| TRANS-4-OCTENE | 3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OCTANE | 6 | 0.5 | 0.3 | 3 | 0.3 | 0.[illegible] | 0.3 | 0.[illegible] |
| UNIDENTIFIED C8 | [illegible] | 0.0 | [illegible].0 | 0 | 0.0 | 0.0 | 0.1 | 0.[illegible] |
| TRANS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,5-TRIMETHYLHEXANE | 3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-ETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.3 | 0.7 | 0.[illegible] | 0.6 |
| ETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLBENZENE | 6 | 0.[illegible] | [illegible].0 | 3 | 0.[illegible] | 0.8 | 0.[illegible] | 0.9 |
| 2,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| m-& p-XYLENE | 8 | 0.5 | 0.8 | 0 | 0.0 | [illegible].7 | 0.0 | [illegible].0 |
| 4-METHYLOCTANE | 3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| STYRENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| o-XYLENE | 0 | 0.3 | 2.1 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-NONENE | 0 | 0.5 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NONANE | 7 | 0.5 | 0.[illegible] | 6 | 0.[illegible] | 0.[illegible] | 0.5 | 0.3 |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| n-PROPYLBENZENE | 3 | 0.3 | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 1-METHYL-3-ETHYLBENZENE | 0 | 0.0 | [illegible].[illegible] | 3 | 0.[illegible] | [illegible].[illegible] | 0.2 | 1.7 |
| 1-METHYL-4-ETHYLBENZENE | 3 | 0.2 | [illegible].[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 1,3,5-TRIMETHYLBENZENE | 3 | 0.2 | 2.1 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 1-METHYL-2-ETHYLBENZENE | 3 | 0.3 | [illegible].0 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 1,2,4-TRIMETHYLBENZENE | 12 | [illegible].0 | 8.6 | 6 | 0.[illegible] | 4.1 | 0.[illegible] | 1.7 |
| DECANE | 7 | 0.5 | 0.[illegible] | 6 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.2 |
| ISOBUTYLBENZENE | 6 | 0.5 | [illegible].0 | 6 | 0.[illegible] | 0.9 | 0.[illegible] | 0.9 |
| METHYLPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S-BUTYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-ISOPROPYLBENZENE | 3 | 0.3 | 1.6 | 3 | 0.2 | 1.4 | 0.2 | 1.4 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 3 | 0.3 | 0.3 | 3 | 0.2 | 0.2 | 0.2 | 0.2 |

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 6 | 0.5 | 3.0 | 5 | 0.4 | 2.4 | 0.4 | 2.5 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 3 | 0.2 | 1.6 | 3 | 0.2 | 1.4 | 0.2 | 1.4 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 4 | 0.3 | 2.9 | 4 | 0.3 | 2.8 | 0.3 | 2.8 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.4 | 0.4 | 0.4 | 0.0 |
| UNDECANE | 16 | 1.3 | [illegible] | 17 | [illegible] | 1.6 | [illegible] | 0.6 |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.4 | 0.4 | 0.4 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 29 | [illegible] | 20.9 | 2.6 | 17.9 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.4 | 0.4 | 0.4 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.0 | 0 | 0.4 | 0.4 | 0.4 | 0.0 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.4 | 0.4 | 0.4 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | [illegible] | [illegible] | [illegible] | [illegible] | 0.3 | 1.6 | 0.3 | 1.5 |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.4 | 0.0 |
| N-PENT-BENZENE | [illegible] | 0.0 | 0.8 | [illegible] | 0.4 | 0.4 | 0.4 | [illegible] |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.4 | 0.0 | 0.4 | 0.0 |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.4 | 0.4 | 0.4 | 0.0 |
| DODECANE | 14 | 0.9 | [illegible] | 14 | 1.1 | 0.4 | 1.1 | 0.0 |
| UNIDENTIFIED C9-C12+ | 49 | 0.0 | 15.2 | 14 | 1.1 | 0.0 | 1.6 | [illegible] |
| FORMALDEHYDE | 527 | 42.9 | 306.8 | 1041 | 85.2 | 609.3 | 79.2 | 566.1 |
| ACETALDEHYDE | 187 | 15.2 | 84.1 | 119 | 9.4 | 53.9 | 10.6 | 58.2 |
| ACROLEIN | 34 | [illegible] | 20.8 | 29 | 2.0 | 13.7 | 2.2 | 14.7 |
| ACETONE | 34 | 3.1 | 1.7 | 34 | [illegible] | 1.1 | 2.6 | 1.4 |
| PROPIONALDEHYDE | 24 | 2.0 | 12.9 | 34 | 2.6 | 16.1 | 2.4 | 15.6 |
| CROTONALDEHYDE | 34 | [illegible] | 15.2 | 29 | 1.6 | 1.6 | [illegible] | 0.8 |
| ISOBUTYRALDEHYDE | 16 | 1.6 | [illegible] | 0 | 0.4 | 1.6 | 2.6 | 2.8 |
| METHYL ETHYL KETONE | 16 | 1.6 | [illegible] | 0 | 0.4 | 0.4 | [illegible] | 0.6 |
| BENZALDEHYDE | 16 | [illegible] | -2.1 | 29 | 2.4 | -1.3 | 2.6 | -1.4 |
| HEXANALDEHYDE | 81 | 6.6 | 25.0 | 64 | 5.2 | 19.7 | 5.4 | 20.5 |
| | | | | | | | | |
| SUMMED SPECIATED VALUES | 2206 | 180 | 1031 | 2131 | 175 | 1089 | 175.2 | 1080.9 |

TEST FUEL: RME20, NO CATALYST
ENGINE: 1995 CUMMINS
TEST DATE: 11/29/95
TEST FUEL: EM-2137-F

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 19 | 1.6 | 0.0 | 161 | 13.2 | 0.2 | 11.5 | 0.2 |
| ETHANE | 4 | 0.3 | 0.1 | 3 | 0.3 | 0.1 | 0.3 | 0.1 |
| ETHYLENE | 375 | 30.6 | 222.8 | 0 | 0.0 | 0.0 | 4.4 | 31.8 |
| PROPANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLENE | 100 | 8.1 | 76.4 | 0 | 0.0 | 0.0 | 1.2 | 10.9 |
| ACETYLENE | 100 | 8.2 | 4.1 | 0 | 0.0 | 0.0 | 1.2 | 0.6 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 4 | 0.3 | 0.3 | 4 | 0.3 | 0.3 | 0.3 | 0.3 |
| TRANS-2-BUTENE | 4 | 0.3 | 3.3 | 0 | 0.0 | 0.0 | 0.0 | 0.5 |
| 1-BUTENE | 28 | 2.3 | 20.5 | 0 | 0.0 | 0.0 | 0.3 | 2.9 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 20 | 1.6 | 8.7 | 0 | 0.0 | 0.0 | 0.2 | 1.2 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 31 | 2.5 | 27.2 | 0 | 0.0 | 0.0 | 0.4 | 3.9 |
| 2-METHYLPROPANE (ISOBUTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 3 | 0.2 | 2.5 | 0 | 0.0 | 0.0 | 0.0 | 0.4 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 11 | 0.9 | 1.2 | 0 | 0.0 | 0.0 | 0.1 | 0.2 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 12 | 0.9 | 5.8 | 0 | 0.0 | 0.0 | 0.1 | 0.8 |
| 2-METHYL-1-BUTENE | 6 | 0.5 | 2.4 | 6 | 0.5 | 2.5 | 0.5 | 2.5 |
| PENTANE | 4 | 0.3 | 0.4 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| UNIDENTIFIED C5 OLEFINS | 5 | 0.4 | 3.7 | 0 | 0.0 | 0.0 | 0.1 | 0.5 |
| 2-METHYL-1,3-BUTADIENE | 4 | 0.3 | 2.8 | 0 | 0.0 | 0.0 | 0.0 | 0.4 |
| TRANS-2-PENTENE | 3 | 0.2 | 2.0 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 3,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-PENTENE | 3 | 0.5 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-BUTENE | 3 | 0.5 | 1.1 | 0 | 0.0 | 0.0 | 0.0 | [illegible] |
| CYCLOPENTADIENE | 3 | 0.0 | 0.5 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLBUTANE | 3 | 0.5 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-1-PENTENE | 3 | [illegible] | 1.1 | 0 | 0.0 | 0.0 | 0.0 | [illegible] |
| 3-METHYL-1-PENTENE | 3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTANE | 3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLBUTANE | 0 | 0.5 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MTBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLPENTANE | 6 | 0.5 | [illegible] | [illegible] | [illegible] | 0.0 | [illegible] | 0.0 |
| 4-METHYL-TRANS-2-PENTENE | 0 | 0.5 | 0.5 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 3-METHYLPENTANE | 0 | [illegible] | 0.5 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 2-METHYL-1-PENTENE | 6 | 0.5 | 2.1 | 0 | 0.0 | 0.0 | 2.1 | [illegible] |
| 1-HEXENE | 6 | 0.5 | 2.1 | 0 | 0.0 | 0.0 | 1.1 | [illegible] |
| HEXANE | 0 | [illegible] | [illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C6 OLEFINS | 12 | [illegible] | 2.1 | 0 | 0.0 | 0.0 | 1.1 | 0.0 |
| TRANS-3-HEXENE | 3 | 0.5 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 5 | 0.4 | 2.8 | 0 | 0.0 | 0.0 | 0.1 | 0.4 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BENZENE | 41 | 3.4 | 1.4 | 0 | 0.0 | 0.0 | 0.5 | 0.2 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLPENTANE | [illegible] | 0.[illegible] | 0.[illegible] | 0 | 0.0 | 0.0 | 0.1 | 0.[illegible] |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,3-DIMETHYLCYCLOPENTANE | [illegible] | 0.[illegible] | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLPENTANE | [illegible] | 0.7 | 0.7 | 0 | 0.0 | 0.0 | 0.1 | 0.[illegible] |
| 2-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-3-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C7 | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOLUENE | 19 | 1.6 | 0.[illegible] | 0 | 0.0 | 0.0 | 0.[illegible] | 0.6 |
| 2,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4,4-TETRAMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 3 | 0.2 | 0.4 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-OCTENE | [illegible] | 0.3 | 0.8 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| TRANS-4-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OCTANE | [illegible] | 0.3 | 0.[illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C8 | [illegible] | 0.3 | 0.3 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| TRANS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-ETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | [illegible] | 0.3 | 0.3 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| ETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLBENZENE | [illegible] | 0.6 | 1.1 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.2 |
| 2,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| m-& p-XYLENE | [illegible] | 0.7 | 5.4 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.8 |
| 4-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| STYRENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| o-XYLENE | [illegible] | 0.6 | [illegible].3 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.[illegible] |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-NONENE | 6 | 0.3 | 1.1 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.2 |
| NONANE | 6 | 0.[illegible] | 0.[illegible] | 0 | 0.0 | 0.0 | 0.[illegible] | 0.0 |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLOCTANE | [illegible] | 0.3 | 0.3 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| n-PROPYLBENZENE | [illegible] | 0.[illegible] | 0.6 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 1-METHYL-3-ETHYLBENZENE | [illegible] | 0.[illegible] | 2.2 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 1-METHYL-4-ETHYLBENZENE | [illegible] | 0.3 | 2.2 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| 1,3,5-TRIMETHYLBENZENE | [illegible] | 0.[illegible] | [illegible].6 | 0 | 0.0 | 0.0 | 0.0 | 0.6 |
| 1-METHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4-TRIMETHYLBENZENE | [illegible] | 0.[illegible] | 6.6 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.9 |
| DECANE | 7 | 0.6 | 0.[illegible] | 1 | 0.[illegible] | 0.1 | 0.[illegible] | 0.1 |
| ISOBUTYLBENZENE | 7 | 0.6 | [illegible].0 | 1 | 0.[illegible] | 0.2 | 0.[illegible] | 0.[illegible] |
| METHYLPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S-BUTYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-ISOPROPYLBENZENE | [illegible] | 2.2 | [illegible] | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 11 | 0.9 | [illegible].0 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.1 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 3 | 0.2 | 1.6 | 0 | 0.0 | 0.0 | 0.0 | 0.2 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 5 | 0.4 | 3.4 | 0 | 0.0 | 0.0 | 0.1 | 0.5 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DODECANE | 16 | [illegible] | 0.5 | 0 | 0.0 | 0.0 | [illegible] | 0.1 |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 39 | 3.1 | 28.5 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | [illegible] | [illegible] | 2.1 | 0 | 0.0 | 0.0 | [illegible] | [illegible] |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| N-PENT-BENZENE | [illegible] | [illegible] | [illegible] | 0 | 0.0 | 0.0 | [illegible] | 0.1 |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NAPHTHALENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DODECANE | 16 | 1.1 | 0.0 | 0 | 0.0 | 0.0 | [illegible] | 0.1 |
| UNIDENTIFIED C9-C12+ | 16 | 1.6 | 0.0 | 0 | 0.0 | 0.0 | [illegible] | 0.9 |
| FORMALDEHYDE | 418 | 34.1 | 243.6 | 266 | 21.9 | 156.2 | 23.6 | 168.7 |
| ACETALDEHYDE | 145 | 11.9 | 65.5 | 99 | 8.1 | 44.7 | 8.6 | 47.7 |
| ACROLEIN | 59 | [illegible] | 32.4 | 17 | [illegible] | [illegible] | 1.3 | 12.8 |
| ACETONE | 34 | 2.8 | 1.5 | 12 | [illegible] | [illegible] | [illegible] | 0.7 |
| PROPIONALDEHYDE | 34 | [illegible] | 18.3 | 28 | 2.3 | 15.1 | [illegible] | 15.5 |
| CROTONALDEHYDE | 27 | 2.2 | 11.9 | 14 | 1.2 | [illegible] | 1.3 | 7.1 |
| ISOBUTYRALDEHYDE | 21 | [illegible] | 9.1 | 14 | 1.2 | [illegible] | 1.3 | [illegible] |
| METHYL ETHYL KETONE | 21 | [illegible] | [illegible] | 14 | 1.2 | 1.4 | 1.3 | 1.5 |
| BENZALDEHYDE | 16 | 1.6 | -0.9 | 13 | [illegible] | -0.6 | 1.1 | -0.6 |
| HEXANALDEHYDE | 37 | 3.0 | 11.3 | 23 | 1.9 | 7.2 | 2.1 | 7.8 |
|  |  |  |  |  |  |  |  |  |
| SUMMED SPECIATED VALUES | 1879 | 153 | 879 | 680 | 56 | 250 | 69.7 | 340.1 |

TEST FUEL: RME20, WITH CATALYST
ENGINE: 1995 CUMMINS
TEST DATE: 11/30/95
TEST FUEL: EM-2137-F

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| METHANE | 214 | 17.4 | 0.3 | 268 | 21.9 | 0.3 | 21.3 | 0.3 |
| ETHANE | 8 | 0.6 | 0.2 | 11 | 0.9 | 0.2 | 0.8 | 0.2 |
| ETHYLENE | 340 | 27.6 | 201.4 | 210 | 17.2 | 125.2 | 18.7 | 136.1 |
| PROPANE | 2 | 0.2 | 0.1 | 3 | 0.3 | 0.1 | 0.3 | 0.1 |
| PROPYLENE | 91 | 7.4 | 69.3 | 56 | 4.6 | 43.1 | 5.0 | 46.9 |
| ACETYLENE | 81 | 6.6 | 3.3 | 52 | 4.3 | 2.1 | 4.6 | 2.3 |
| PROPADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BUTANE | 8 | 0.6 | 0.6 | 15 | 1.3 | 1.3 | 1.2 | 1.2 |
| TRANS-2-BUTENE | 5 | 0.4 | 4.0 | 4 | 0.3 | 3.0 | 0.3 | 3.1 |
| 1-BUTENE | 23 | 1.8 | 16.4 | 13 | 1.1 | 9.7 | 1.2 | 10.6 |
| 2-METHYLPROPENE (ISOBUTYLENE) | 18 | 1.4 | 7.6 | 12 | 1.0 | 5.1 | 1.0 | 5.5 |
| 2,2-DIMETHYLPROPANE (NEOPENTANE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PROPYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-BUTADIENE | 27 | 2.2 | 23.5 | 15 | 1.2 | 13.4 | 1.4 | 14.8 |
| 2-METHYLPROPANE (ISOBUTANE) | 4 | 0.4 | 0.4 | 27 | 2.2 | 2.7 | 2.0 | 2.4 |
| 1-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-BUTENE | 4 | 0.4 | 3.5 | 3 | 0.2 | 2.3 | 0.3 | 2.5 |
| 3-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHANOL | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLBUTANE (ISOPENTANE) | 22 | 1.8 | 2.5 | 67 | 5.5 | 7.6 | 5.0 | 6.9 |
| 2-BUTYNE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-PENTENE | 10 | 0.8 | 4.8 | 3 | 0.2 | 1.5 | 0.3 | 1.9 |
| 2-METHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PENTANE | 3 | 0.3 | 0.3 | 8 | 0.6 | 0.7 | 0.6 | 0.6 |
| UNIDENTIFIED C5 OLEFINS | 9 | 0.7 | 6.2 | 6 | 0.5 | 4.5 | 0.5 | 4.8 |
| 2-METHYL-1,3-BUTADIENE | 3 | 0.3 | 2.3 | 0 | 0.0 | 0.0 | 0.0 | 0.3 |
| TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-PENTENE | 0 | 0.0 | 0.0 | [illegible] | 0.[illegible] | 2.1 | 0.[illegible] | [illegible].8 |
| 2-METHYL-2-BUTENE | 4 | 0.[illegible] | [illegible].0 | 0 | 0.0 | 0.0 | 0.0 | 0.[illegible] |
| CYCLOPENTADIENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLBUTANE | 8 | 0.6 | 0.[illegible] | [illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] |
| MTBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLPENTANE | [illegible] | 0.1 | 0.[illegible] | [illegible] | 0.[illegible] | 0.4 | 0.[illegible] | 0.[illegible] |
| 4-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLPENTANE | 0 | 0.[illegible] | 0.[illegible] | 0 | 0.[illegible] | 0.4 | 0.[illegible] | 0.0 |
| 2-METHYL-1-PENTENE | 0 | 0.[illegible] | 1.3 | [illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] | [illegible].0 |
| 1-HEXENE | 4 | 0.[illegible] | [illegible] | [illegible] | 0.[illegible] | 0.[illegible] | 0.[illegible] | [illegible].0 |
| HEXANE | [illegible] | 0.[illegible] | 0.[illegible] | [illegible] | 0.[illegible] | 0.[illegible] | 0.3 | 0.[illegible] |
| UNIDENTIFIED C6 OLEFINS | 6 | 0.[illegible] | 3.4 | 0 | 0.[illegible] | 2.2 | 0.[illegible] | 2.4 |
| TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.3 | 0.0 |
| 3-METHYL-TRANS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETBE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

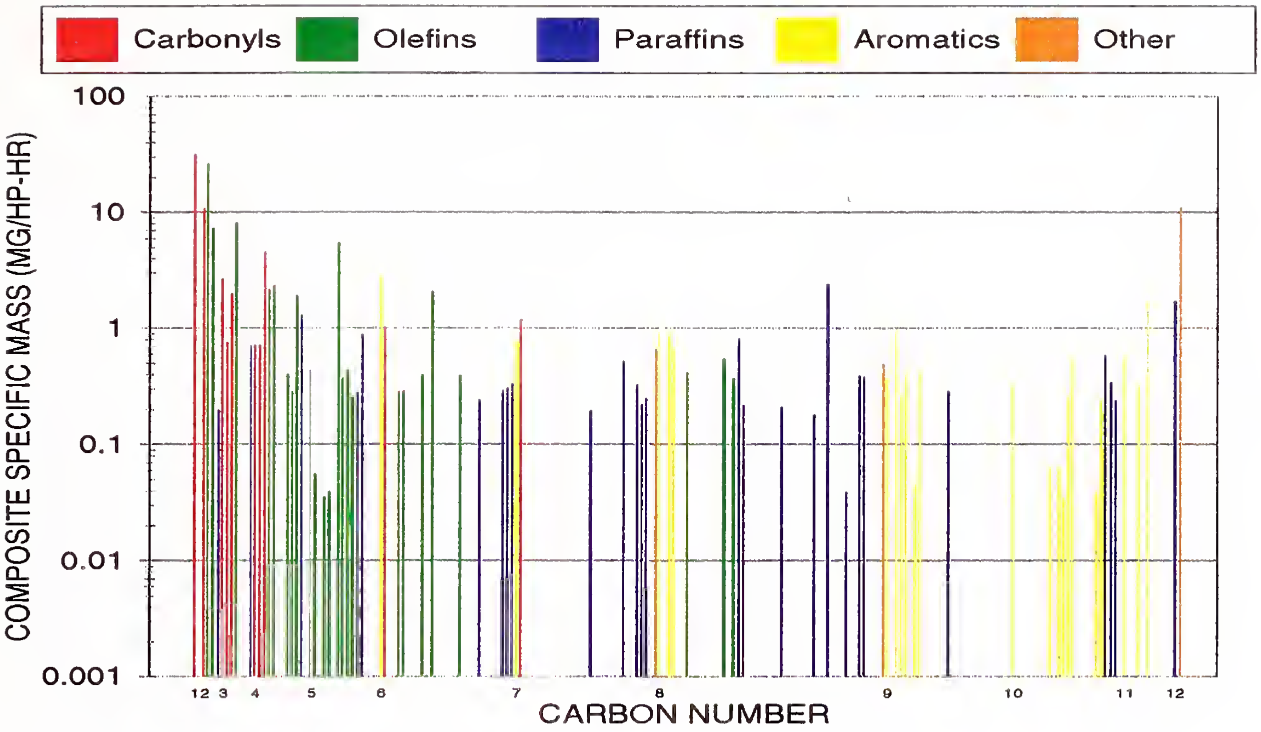
| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 3-METHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYL-1-BUTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLBUTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYLCYCLOPENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BENZENE | 33 | 2.7 | 1.1 | 23 | 1.9 | 0.8 | 2.0 | 0.8 |
| 3-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYLPENTANE | 1 | [illegible] | 0.2 | 0 | 0.0 | [illegible] | [illegible] | [illegible] |
| 1,1-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYCLOHEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,3-DIMETHYLCYCLOPENTANE | 0 | [illegible] | 0.0 | 0 | 0.0 | 0.0 | 0.0 | [illegible] |
| 3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLPENTANE | 8 | 0.6 | 0.6 | 6 | [illegible] | 0.0 | [illegible] | [illegible] |
| 2-METHYL-1-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-3-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNIDENTIFIED C7 | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-2-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYL-TRANS-3-HEXENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYL-CIS-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYL-1-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3-DIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-2-HEPTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| METHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYL-2-PENTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,5-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,4-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,3,3-TRIMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOLUENE | 22 | 1.7 | 0.8 | 16 | 1.3 | 3.7 | [illegible] | [illegible] |
| 2,3-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1,2-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4-DIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4,4-TETRAMETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYL-3-ETHYLPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD |  |  | HOT |  |  | COMPOSITE |  |
|---|---|---|---|---|---|---|---|---|
|  | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| CIS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,4-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-ETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CIS-1-METHYL-3-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,1-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-1-ETHYL-CYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,2,4-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRANS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.1 | 0 | 0.1 | 0.0 | 0.0 | 0.1 |
| 1-OCTENE | [illegible] | 0.2 | 0.6 | 0 | 0.0 | 0.0 | 0.1 | 0.1 |
| TRANS-4-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.1 | 0.0 | 0.1 | 0.1 |
| OCTANE | 3 | 0.[illegible] | 0.[illegible] | 3 | 0.3 | 0.2 | 0.3 | 0.2 |
| UNIDENTIFIED C8 | [illegible] | 0.3 | 0.9 | [illegible] | 0.2 | 0.8 | 0.2 | 0.8 |
| TRANS-2-OCTENE | 0 | 0.0 | 0.1 | 0 | 0.1 | 0.0 | 0.0 | 0.0 |
| TRANS-1,3-DIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.1 | 0.1 |
| CIS-1,4-DIMETHYLCYCLOHEXANE | 8 | 0.0 | 0.0 | 0 | 0.1 | 0.0 | 0.1 | 0.1 |
| CIS-2-OCTENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 2,3,5-TRIMETHYLHEXANE | 0 | 0.0 | 0.1 | 0 | 0.1 | 0.0 | 0.0 | 0.1 |
| CIS-1-METHYL-2-ETHYLCYCLOPENTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 2-METHYL-2-ETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.1 | 0 | 0.1 | 0.0 | 0.1 | 0.1 |
| 4,4-DIMETHYLHEPTANE | 0 | 0.0 | 0.1 | 0 | 0.1 | 0.0 | 0.0 | 0.0 |
| CIS-1,2-DIMETHYLCYCLOHEXANE | 0 | 0.3 | 0.6 | 3 | 0.3 | 0.[illegible] | 0.3 | 0.[illegible] |
| ETHYLCYCLOHEXANE | 0 | 0.0 | 0.1 | 0 | 0.8 | 0.0 | 0.0 | 0.0 |
| PROPYLCYCLOHEXANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.1 | 0.1 |
| 2-METHYL-4-ETHYLHEXANE | 0 | 0.0 | 0.1 | 0 | 0.1 | 0.0 | 0.0 | 0.0 |
| 2,6-DIMETHYLHEPTANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.1 | 0.1 |
| 1,1,3-TRIMETHYLCYCLOHEXANE | 0 | 0.0 | 0.1 | 0 | 0.1 | 0.0 | 0.1 | 0.1 |
| 2,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.1 | 0 | 0.1 | 0.0 | 0.1 | 0.1 |
| 3,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,5-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ETHYLBENZENE | [illegible] | 0.[illegible] | 0.6 | [illegible] | 0.2 | 0.6 | 0.2 | 0.6 |
| 2,3-DIMETHYLHEPTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.1 | 0.1 |
| m-& p-XYLENE | 6 | 0.5 | [illegible].1 | [illegible] | 0.1 | [illegible].0 | 0.1 | 3.0 |
| 4-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3-METHYLOCTANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| STYRENE | 0 | 0.0 | 0.0 | 0 | 0.1 | 0.0 | 0.1 | 0.1 |
| o-XYLENE | [illegible] | 0.2 | 1.4 | 0 | 0.0 | 0.0 | 0.1 | 0.2 |
| 2,4,6-TRIMETHYLHEXANE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-NONENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.1 | 0.0 |
| NONANE | [illegible] | 0.0 | 0.2 | [illegible] | 0.0 | 0.2 | 0.1 | 0.2 |
| ISOPROPYLBENZENE (CUMENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.1 | 0.1 |
| 2,2-DIMETHYLOCTANE | 0 | 0.0 | 0.1 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 2,4-DIMETHYLOCTANE | [illegible] | 0.2 | 0.2 | [illegible] | 0.[illegible] | 0.2 | 0.2 | 0.2 |
| n-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 1-METHYL-3-ETHYLBENZENE | [illegible] | 0.[illegible] | [illegible].0 | [illegible] | 0.[illegible] | [illegible].9 | 0.3 | 1.9 |
| 1-METHYL-4-ETHYLBENZENE | [illegible] | 0.2 | 1.6 | 0 | 0.0 | 0.0 | 0.1 | 0.2 |
| 1,3,5-TRIMETHYLBENZENE | [illegible] | 0.[illegible] | [illegible].9 | [illegible] | 0.[illegible] | 2.1 | 0.2 | [illegible].2 |
| 1-METHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.1 | 0.1 |
| 1,2,4-TRIMETHYLBENZENE | 6 | 0.5 | 1.6 | [illegible] | 0.3 | 2.1 | 0.3 | [illegible].2 |
| DECANE | 7 | 0.6 | 0.[illegible] | 7 | 0.[illegible] | 0.3 | 0.6 | 0.3 |
| ISOBUTYLBENZENE | 7 | 0.[illegible] | 1.6 | 6 | 0.[illegible] | [illegible].0 | 0.[illegible] | 1.0 |
| METHYLPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.1 | 0.0 | 0.1 | 0.1 |
| S-BUTYLBENZENE | 0 | 0.0 | 0.1 | 0 | 0.1 | 0.0 | 0.1 | 0.1 |
| 1-METHYL-3-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3-TRIMETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| INDAN | 3 | 0.2 | 0.2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |

| COMPOUND | COLD | | | HOT | | | COMPOSITE | |
|---|---|---|---|---|---|---|---|---|
| | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG | MG/BHP-HR | OZONE, MG/BHP-HR | MG/BHP-HR | OZONE, MG/BHP-HR |
| 1-METHYL-2-ISOPROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-3-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-4-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2 DIETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-METHYL-2-N-PROPYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,4-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2-DIMETHYL-4-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,3-DIMETHYL-2-ETHYLBENZENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UNDECANE | 15 | 1.2 | 0.[illegible] | 15 | 1.2 | 0.5 | 1.2 | 0.[illegible] |
| 1,2-DIMETHYL-3-ETHYLBENZENE | 0 | 0.4 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,4,5-TETRAMETHYLBENZENE | 29 | [illegible].4 | 21.3 | 37 | 3.1 | 27.7 | [illegible].0 | 25.9 |
| 2-METHYLBUTYLBENZENE (sec AMYLBENZENE) | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3,4 DIMETHYLCUMENE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1,2,3,5-TETRAMETHYLBENZENE | 0 | 0.4 | 0.0 | 0 | 3.0 | 0.0 | 0.0 | 0.0 |
| TERT-1-BUT-2-METHYLBENZENE | 0 | 0.0 | 0.0 | [illegible] | 3.9 | 1.3 | 0.[illegible] | [illegible] |
| 1,2,3,4-TETRAMETHYLBENZENE | 0 | 0.4 | 0.0 | 0 | 3.0 | 0.0 | 0.0 | 0.0 |
| N-PENT-BENZENE | 0 | 0.[illegible] | 0.6 | 0 | 0.[illegible] | 0.[illegible] | 0.[illegible] | 0.5 |
| TERT-1-BUT-3,5-DIMETHYLBENZENE | 0 | 0.4 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NAPHTHALENE | 0 | 0.4 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DODECANE | 10 | 0.4 | 0.[illegible] | 13 | [illegible] | 0.0 | [illegible] | 0.0 |
| UNIDENTIFIED C9-C12+ | 10 | 0.8 | [illegible] | 13 | [illegible].0 | [illegible] | [illegible].0 | 3.9 |
| FORMALDEHYDE | 514 | 41.7 | 298.4 | 316 | 25.9 | 184.8 | 28.1 | 201.1 |
| ACETALDEHYDE | 232 | 18.8 | 103.9 | 151 | 12.3 | 68.1 | 13.3 | 73.3 |
| ACROLEIN | 60 | 0.4 | 33.2 | 118 | 9.6 | 65.0 | 8.9 | 60.5 |
| ACETONE | 65 | 5.3 | [illegible].0 | 36 | 3.9 | 1.6 | [illegible] | 1.8 |
| PROPIONALDEHYDE | 46 | [illegible].4 | 24.6 | 29 | 1.9 | 12.1 | 2.1 | 13.9 |
| CROTONALDEHYDE | 0 | 0.4 | 1.9 | 0 | 0.0 | 0.0 | 0.[illegible] | 0.[illegible] |
| ISOBUTYRALDEHYDE | 16 | [illegible].4 | 7.5 | 8 | 0.6 | 3.3 | 0.7 | 3.9 |
| METHYL ETHYL KETONE | 18 | 1.7 | 1.7 | 8 | 0.6 | 0.7 | 0.7 | 0.9 |
| BENZALDEHYDE | 21 | 1.7 | -0.9 | 0 | 0.0 | 0.0 | 0.[illegible] | -0.1 |
| HEXANALDEHYDE | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | | |
| SUMMED SPECIATED VALUES | 2084 | 169 | 884 | 1637 | 134 | 619 | 138.8 | 656.6 |

# APPENDIX C

# $C_1$ - $C_{12}$ SPECIATION GRAPHS



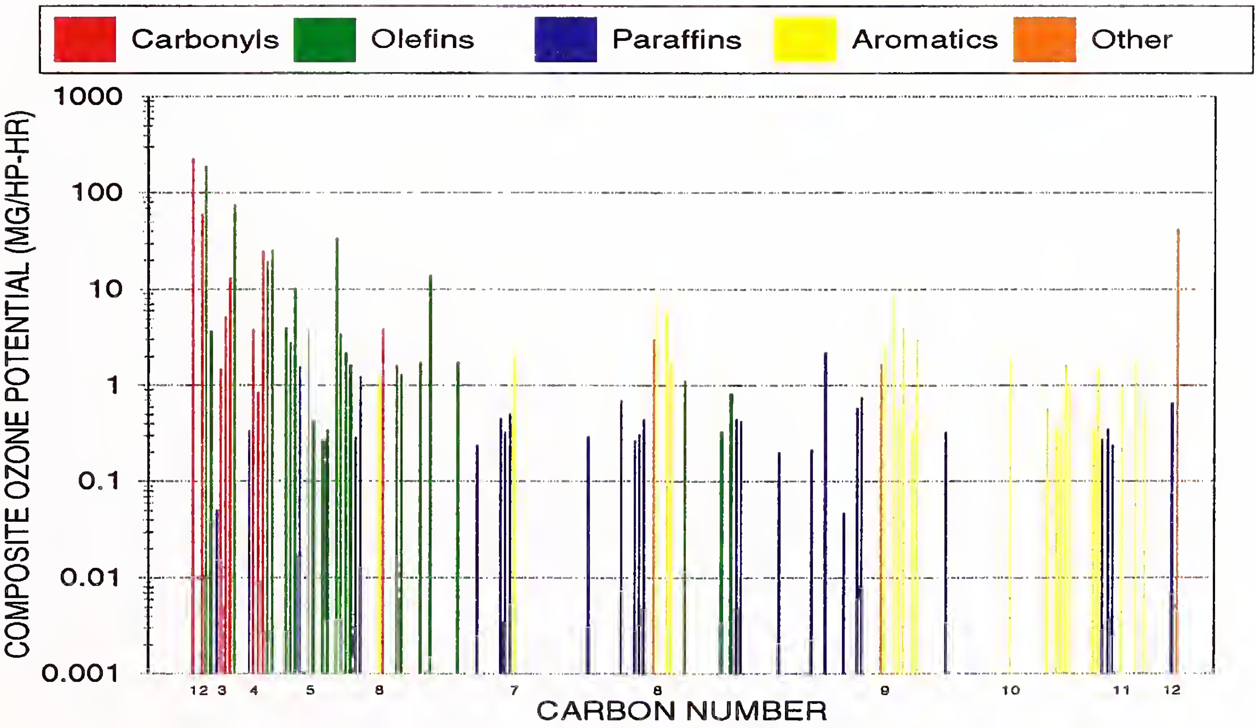


**FIGURE C-1. C1 - C12 SPECIATION DATA FOR 2-D FUEL WITHOUT CATALYST**

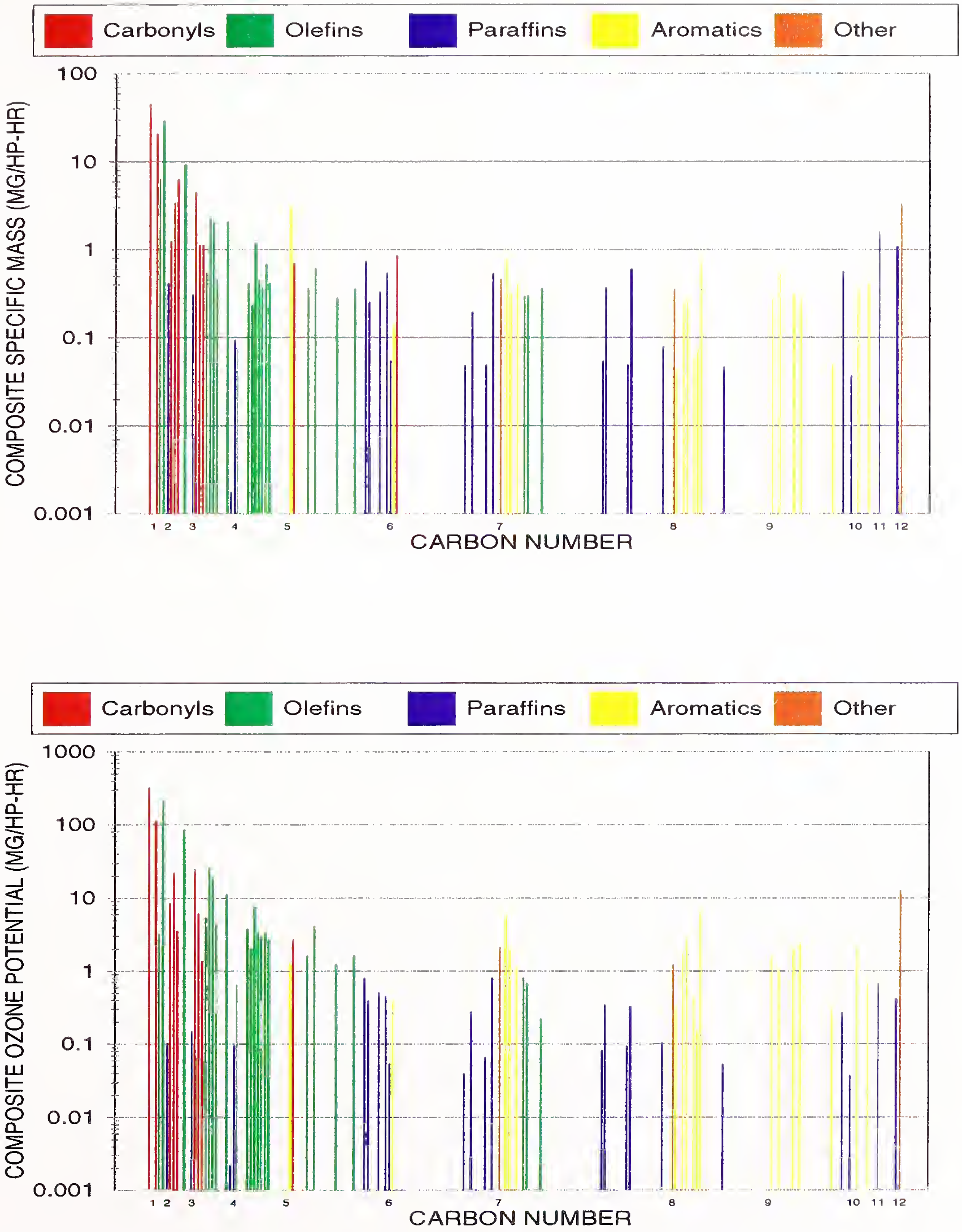
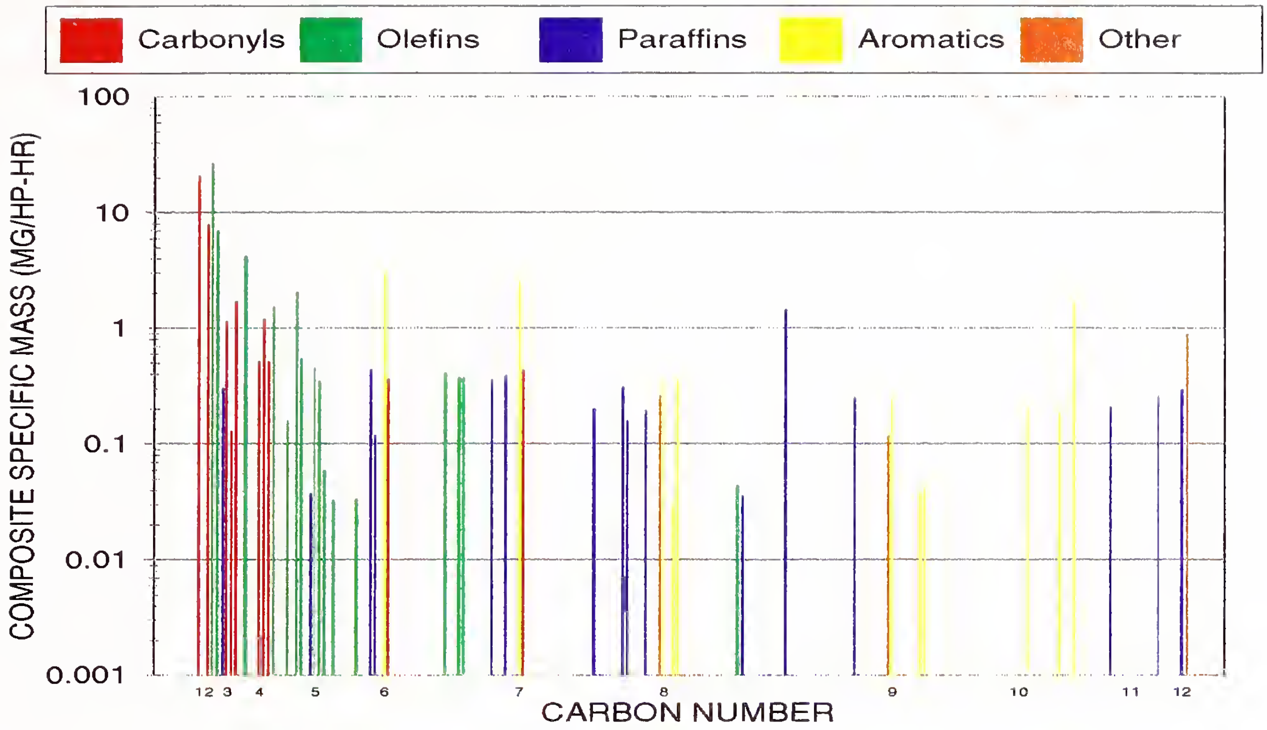


FIGURE C-2. C1 - C12 SPECIATION DATA FOR 2-D FUEL WITH CATALYST



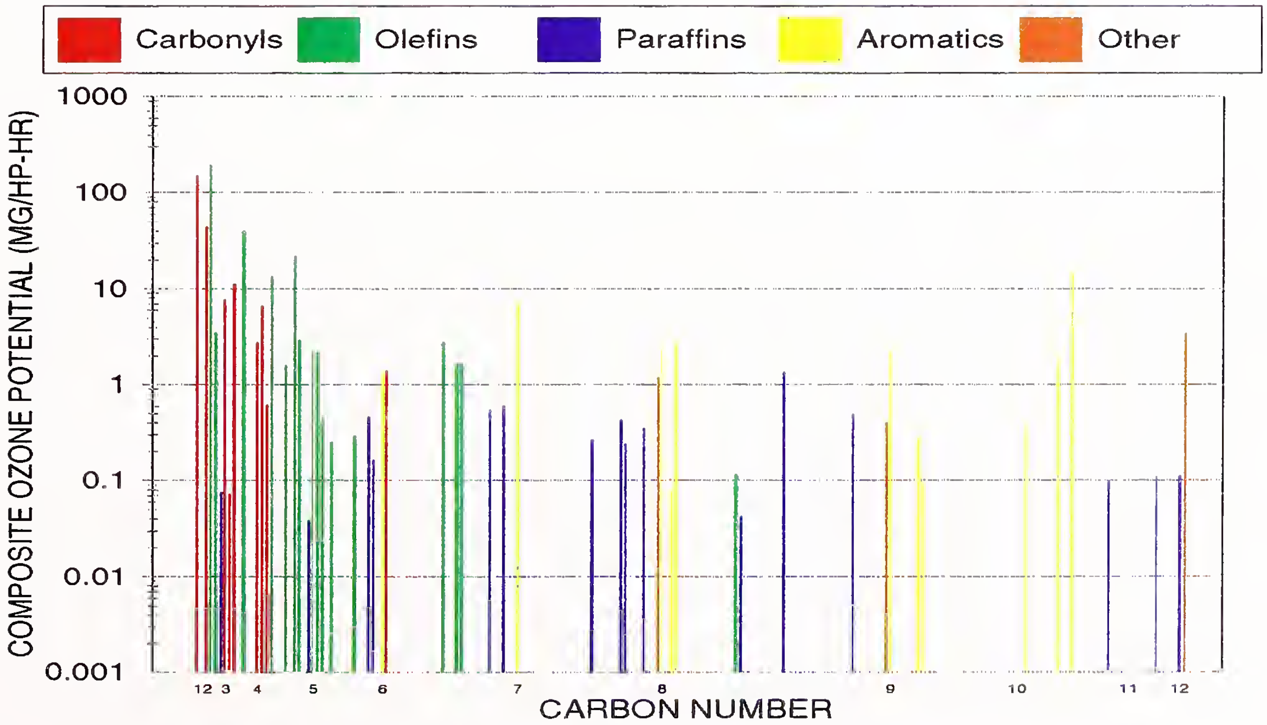


**FIGURE C-3. C1 - C12 SPECIATION DATA FOR REE WITHOUT CATALYST**

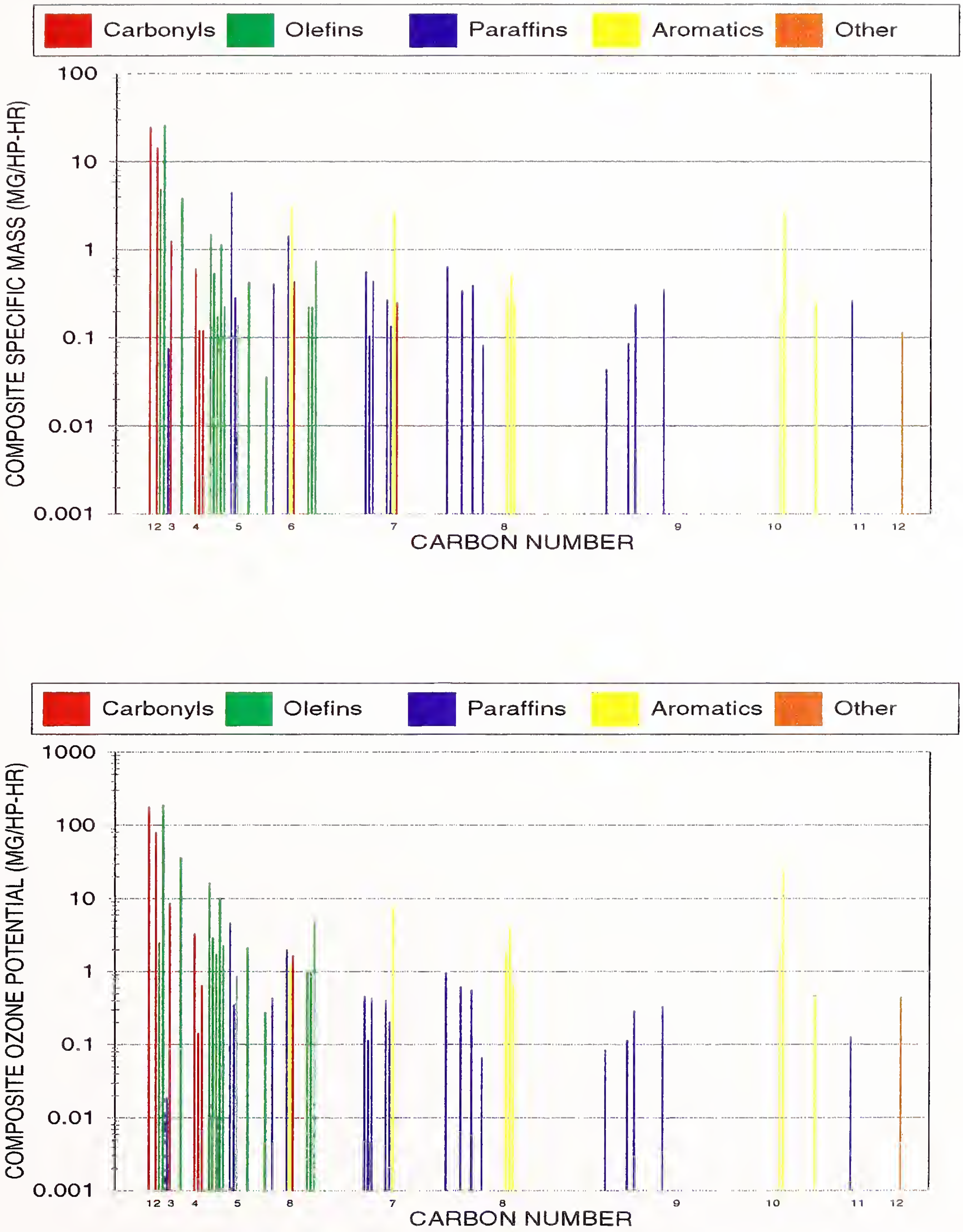
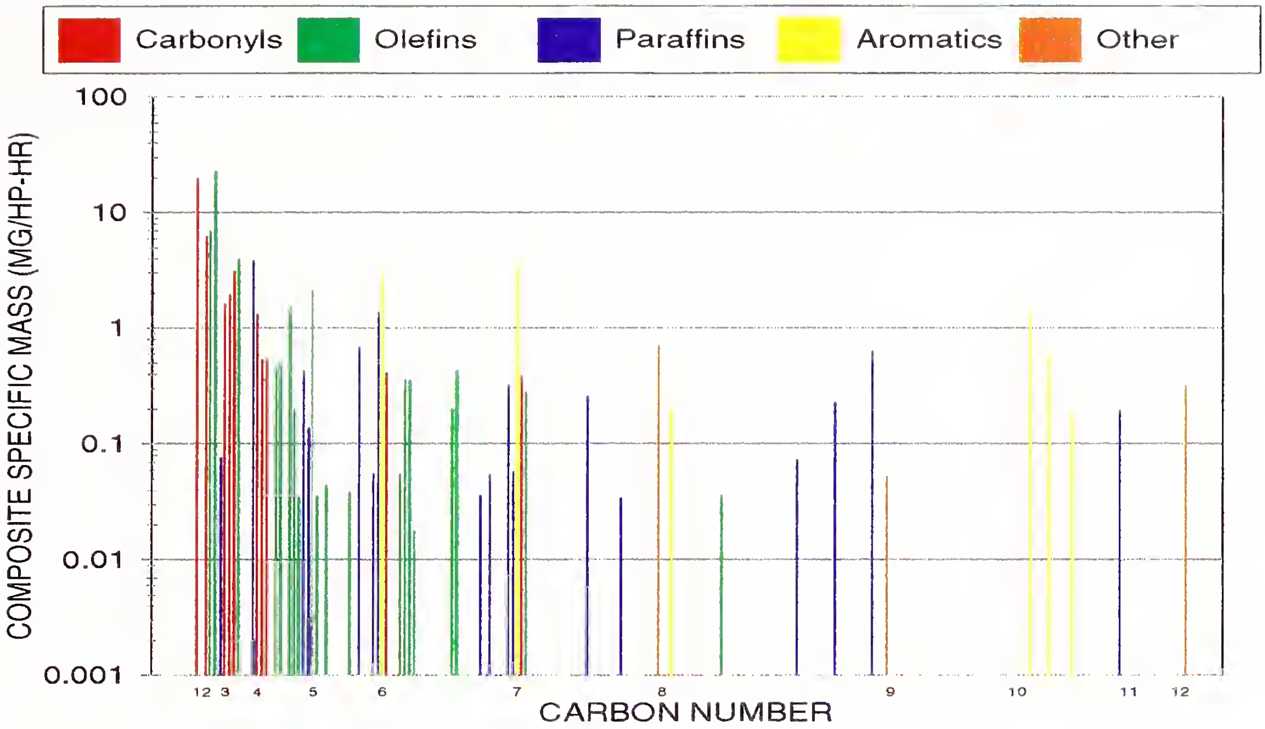


FIGURE C-4. C1 - C12 SPECIATION DATA FOR REE WITH CATALYST



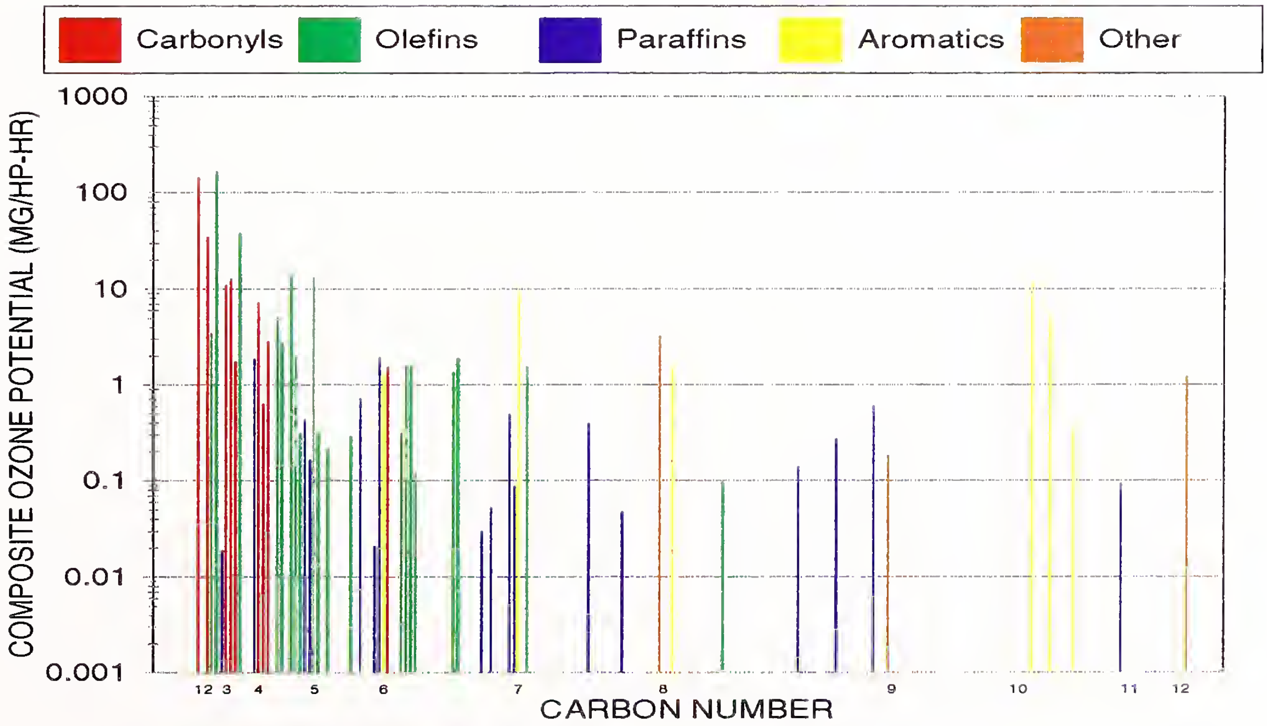
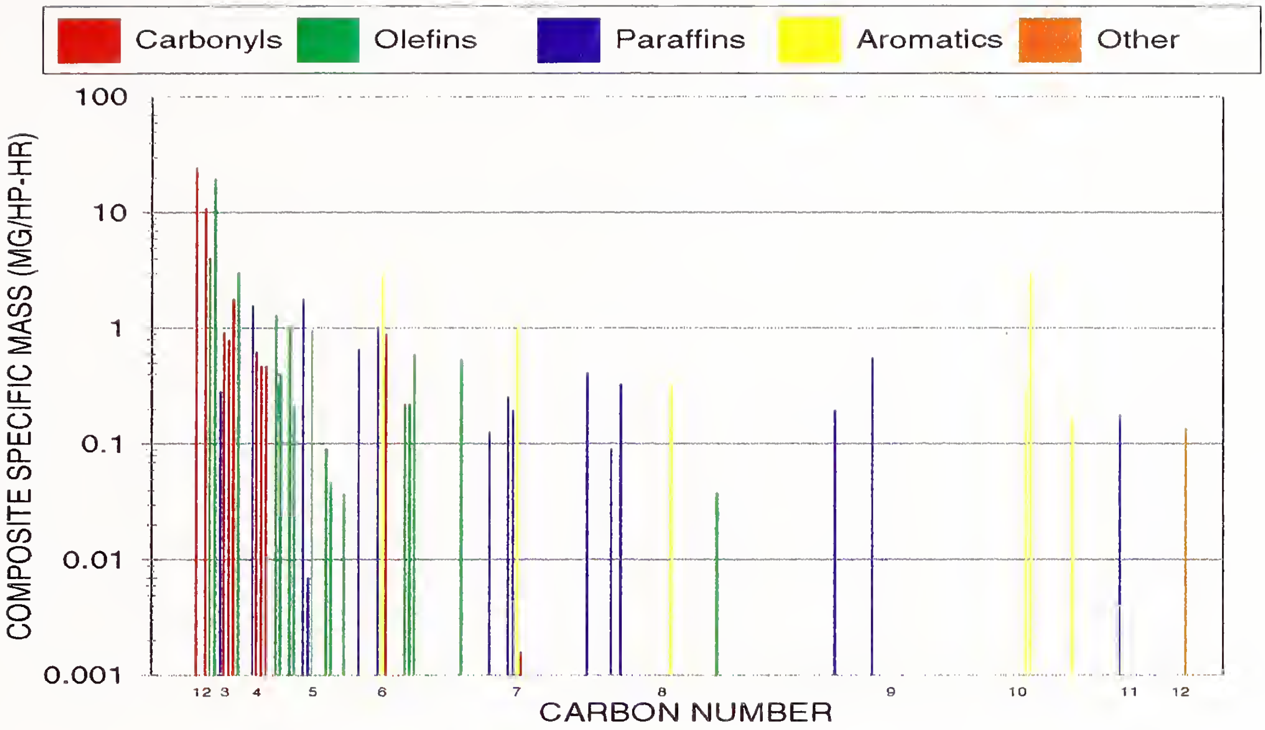


**FIGURE C-5. C1 - C12 SPECIATION DATA FOR RME WITHOUT CATALYST**



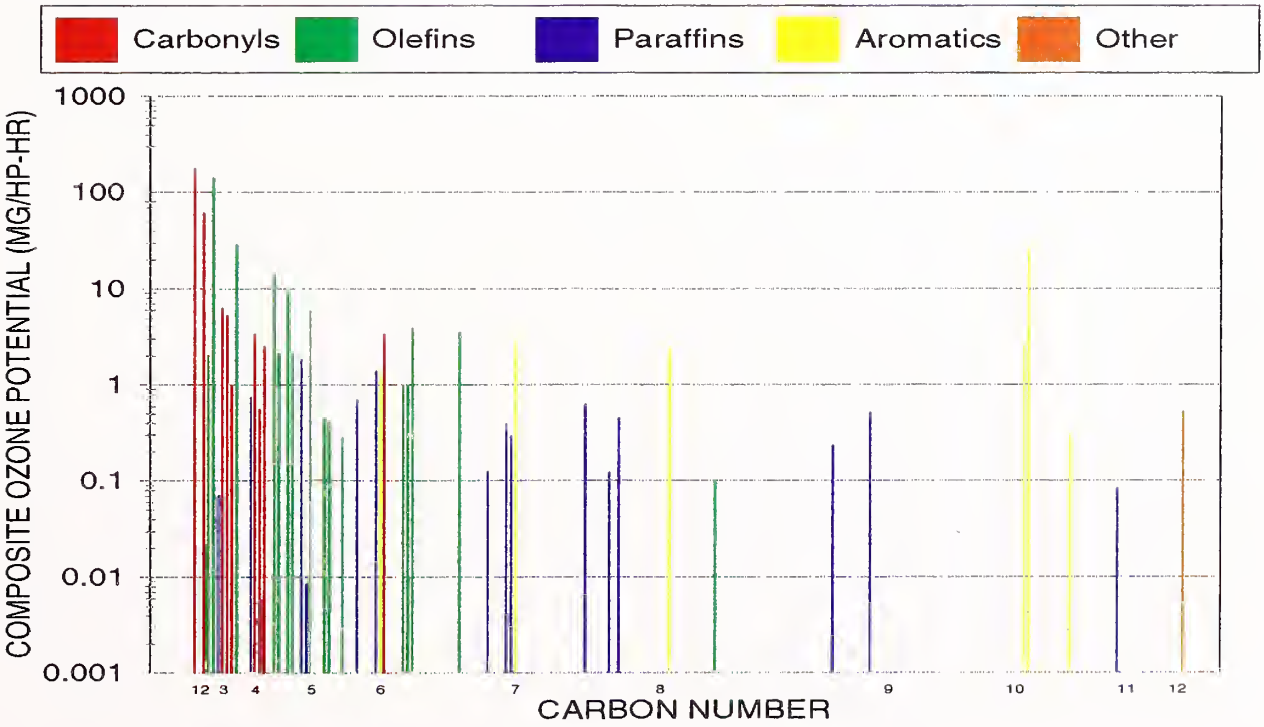


**FIGURE C-6. C1 - C12 SPECIATION DATA FOR RME WITH CATALYST**

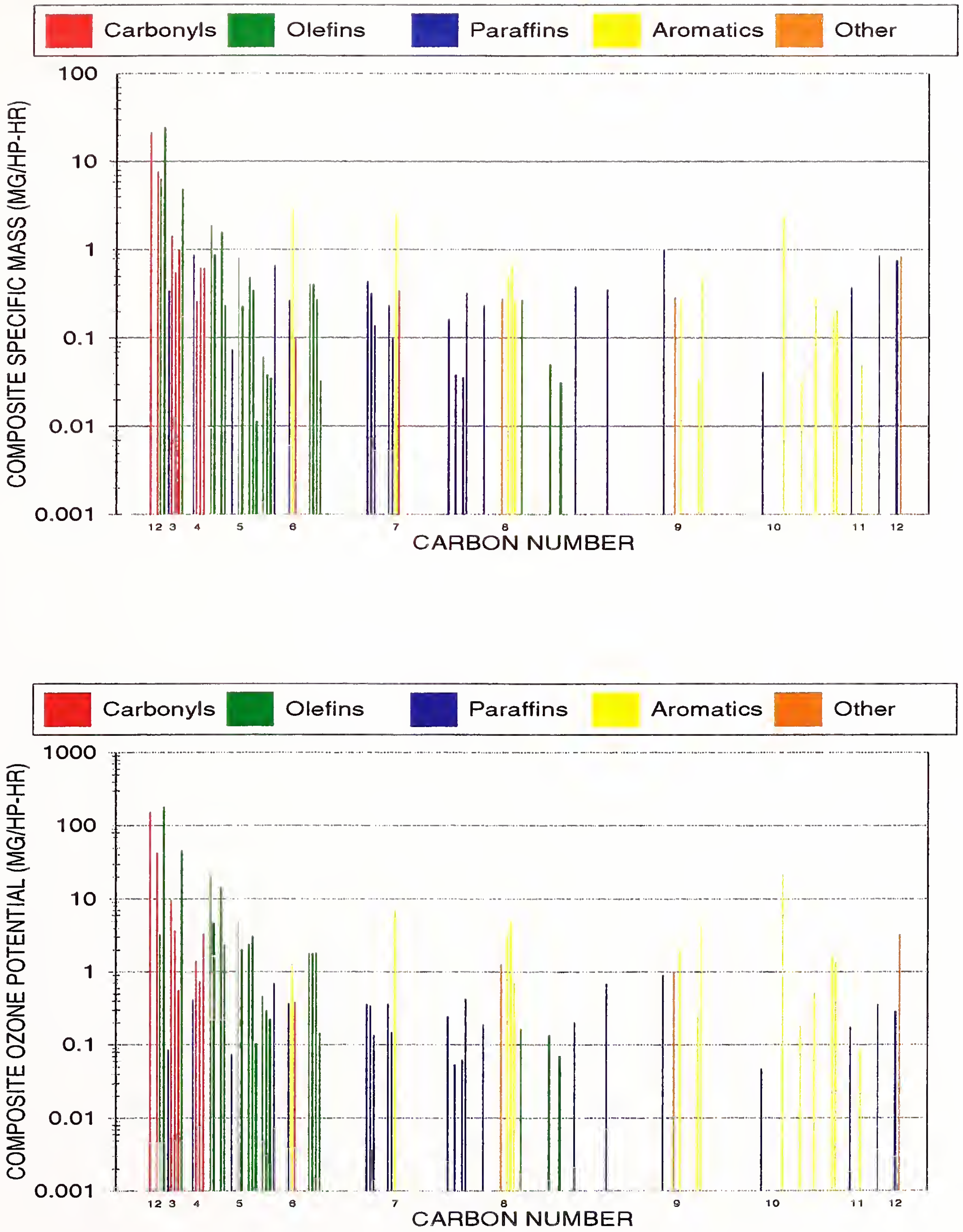


**FIGURE C-7. C1 - C12 SPECIATION DATA FOR REE50 WITHOUT CATALYST**

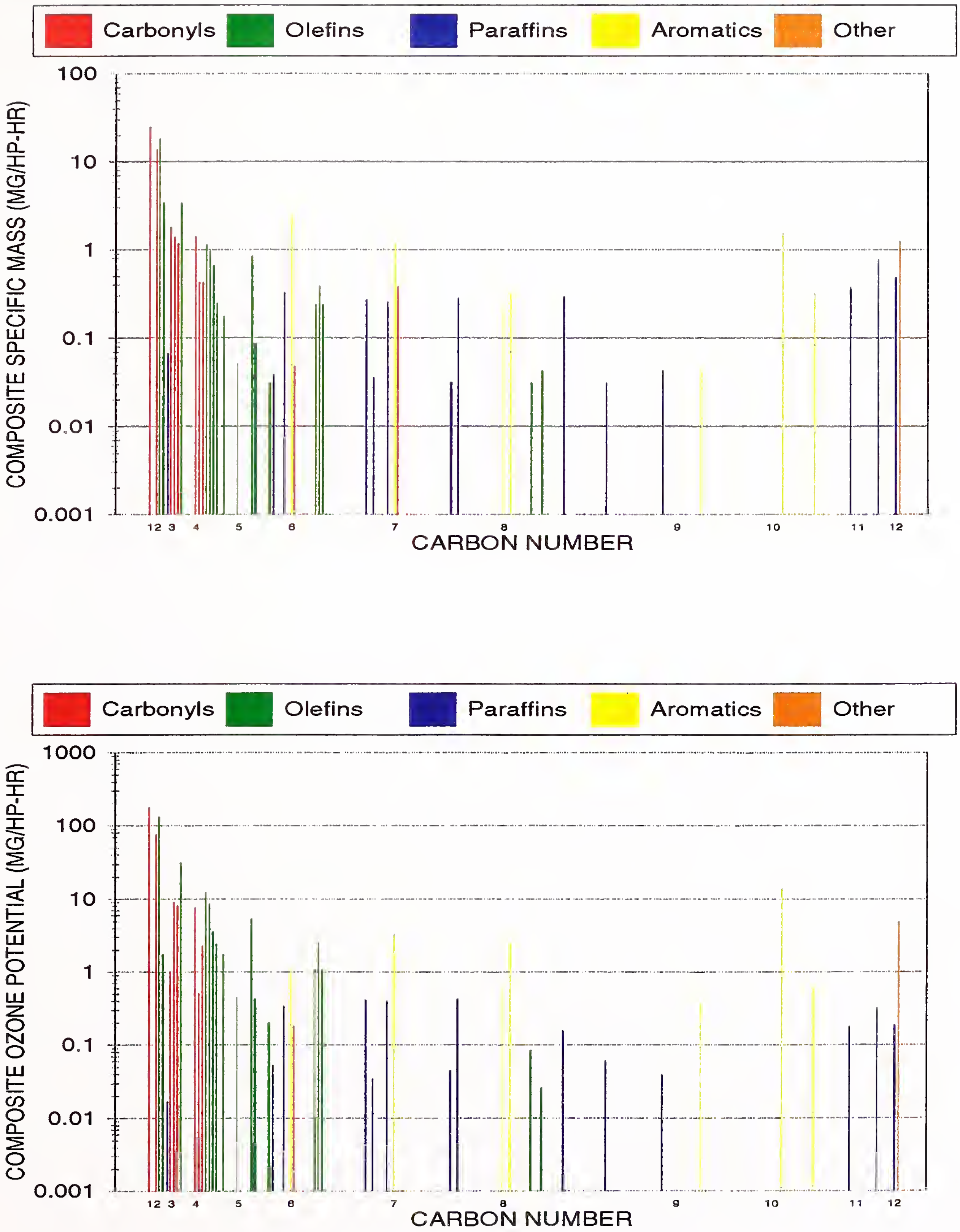
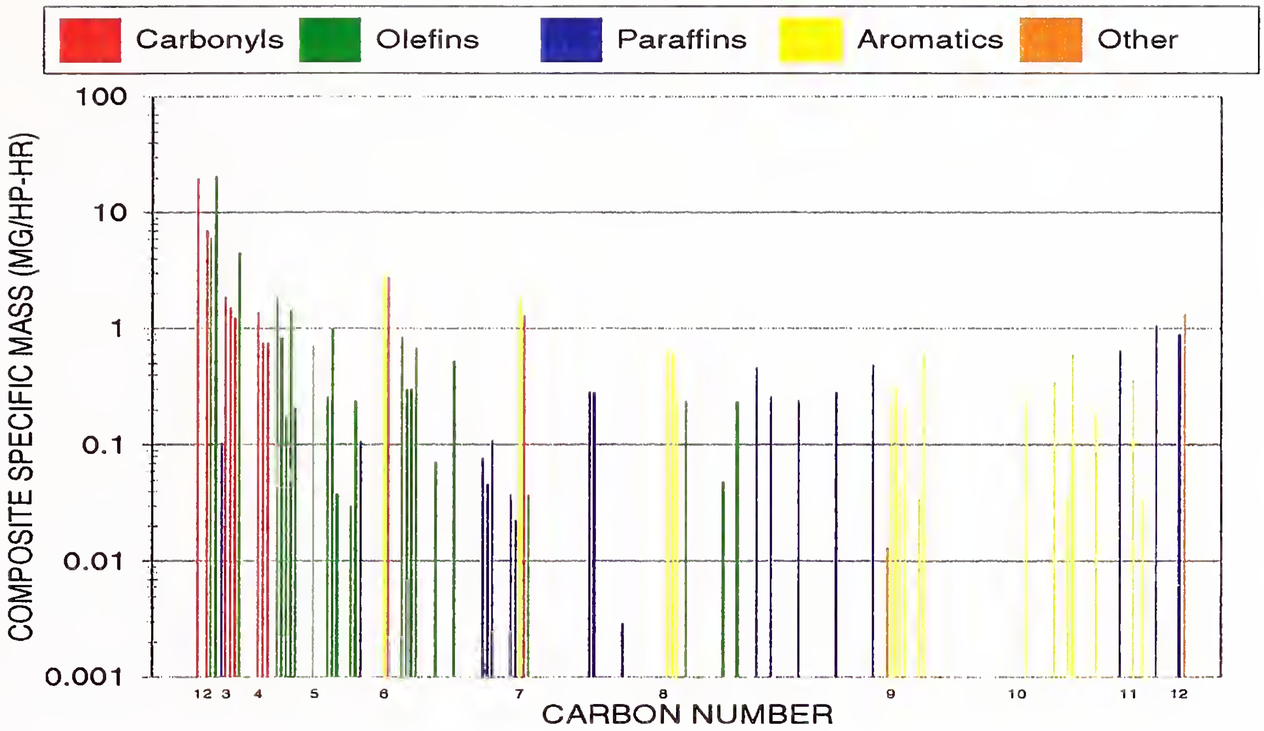


**FIGURE C-8. C1 - C12 SPECIATION DATA FOR REE50 WITH CATALYST**



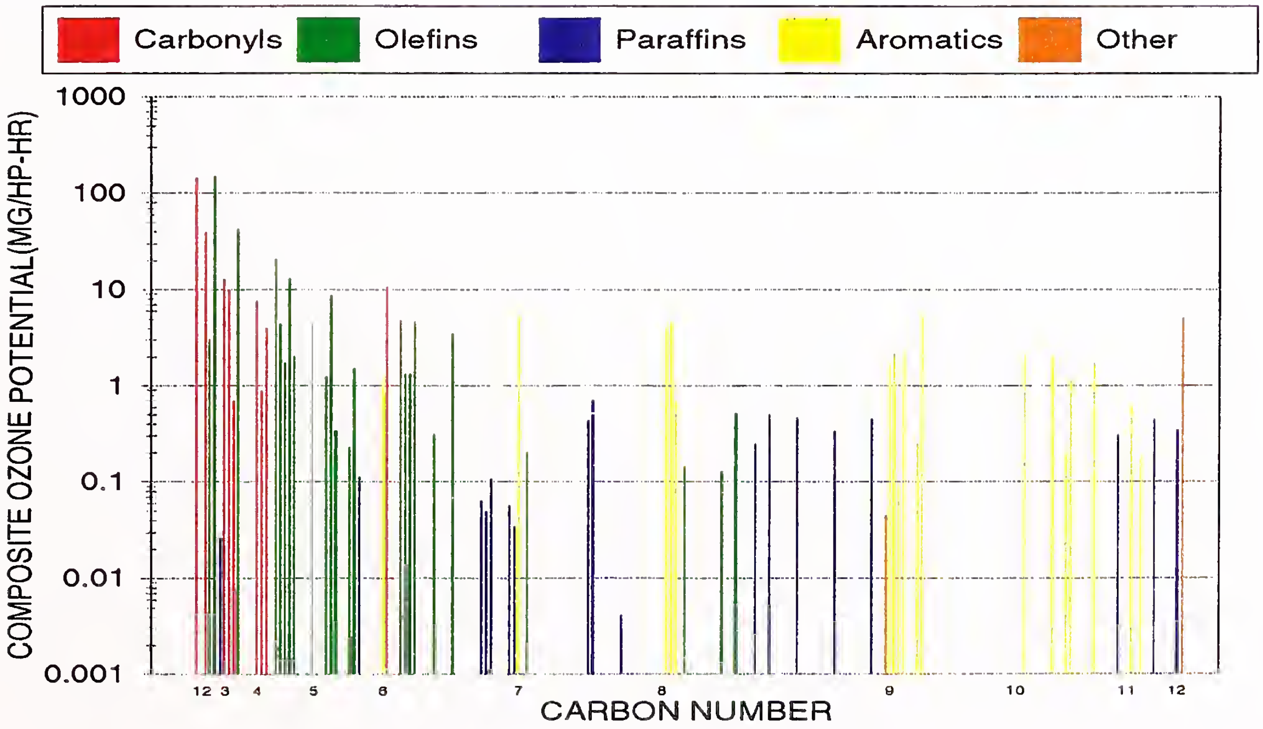


**FIGURE C-9. C1 - C12 SPECIATION DATA FOR RME50 WITHOUT CATALYST**

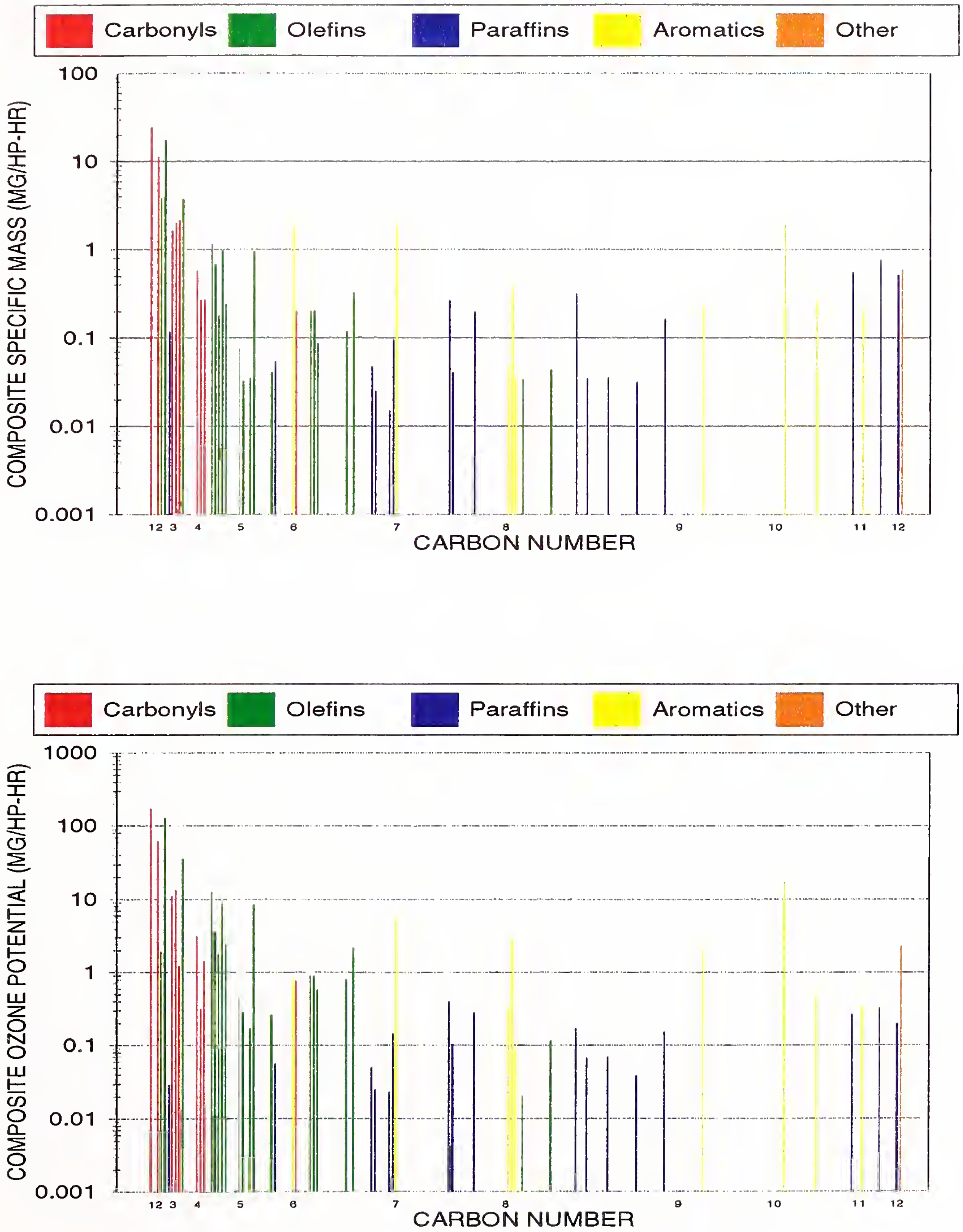


**FIGURE C-10. C1 - C12 SPECIATION DATA FOR RME50 WITH CATALYST**

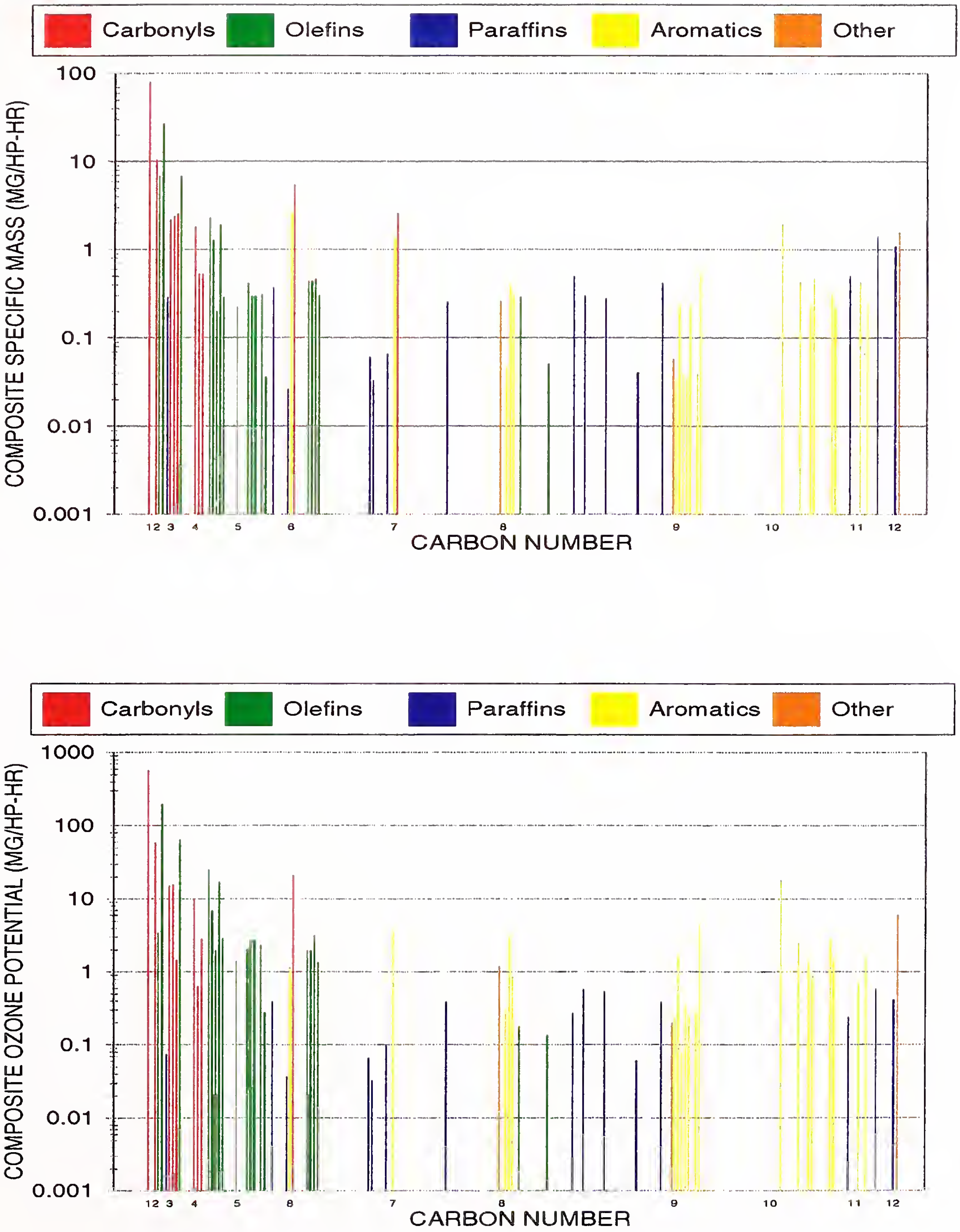
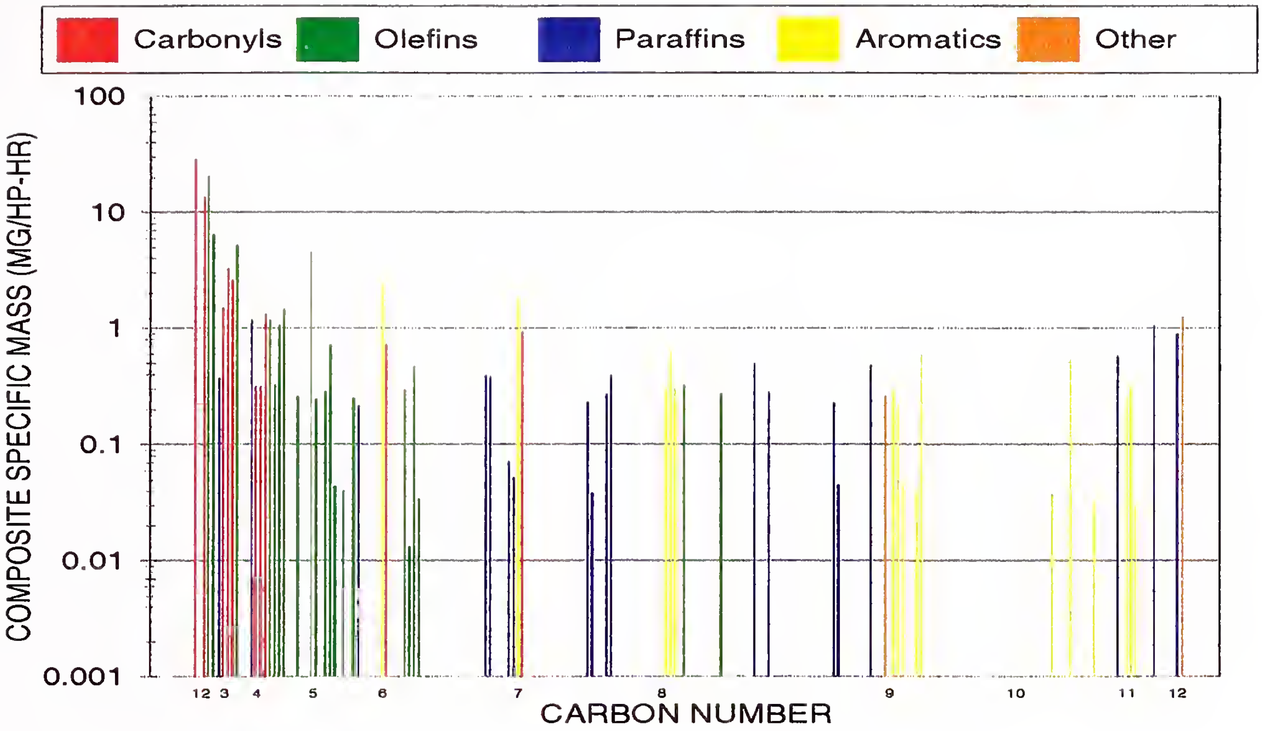


**FIGURE C-11. C1 - C12 SPECIATION DATA FOR REE20 WITHOUT CATALYST**



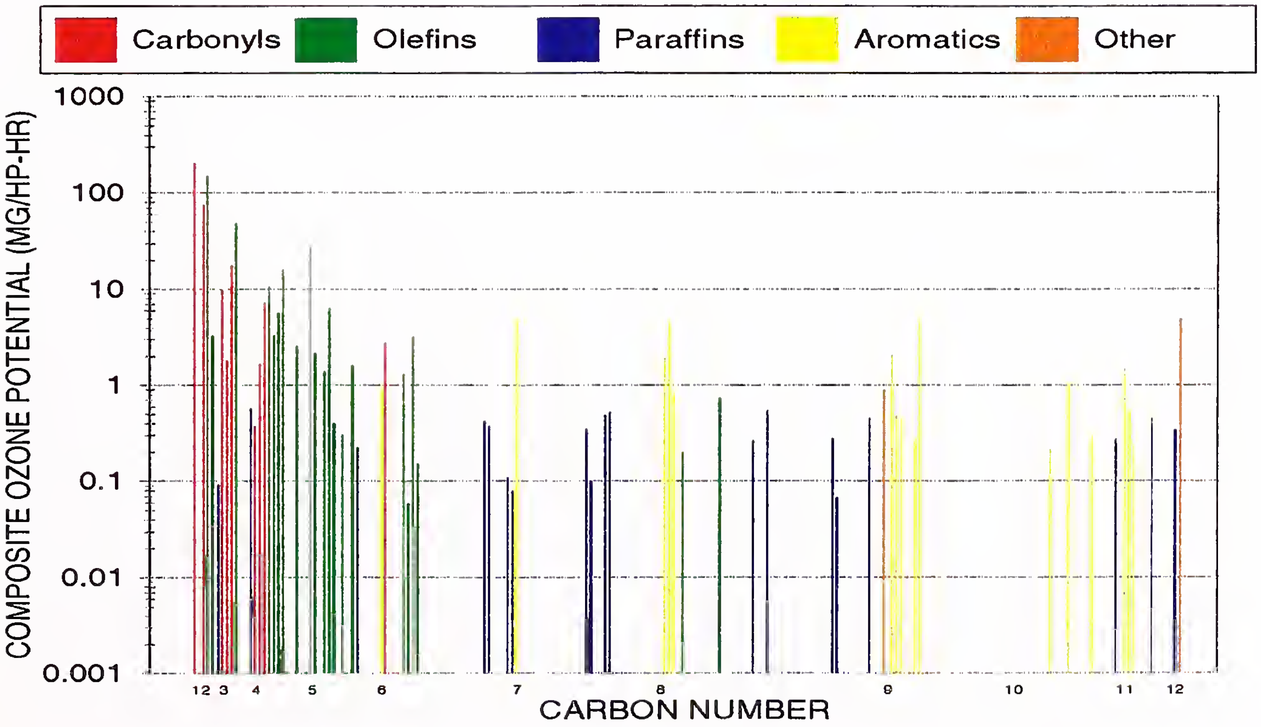


FIGURE C-12. C1 - C12 SPECIATION DATA FOR REE20 WITH CATALYST

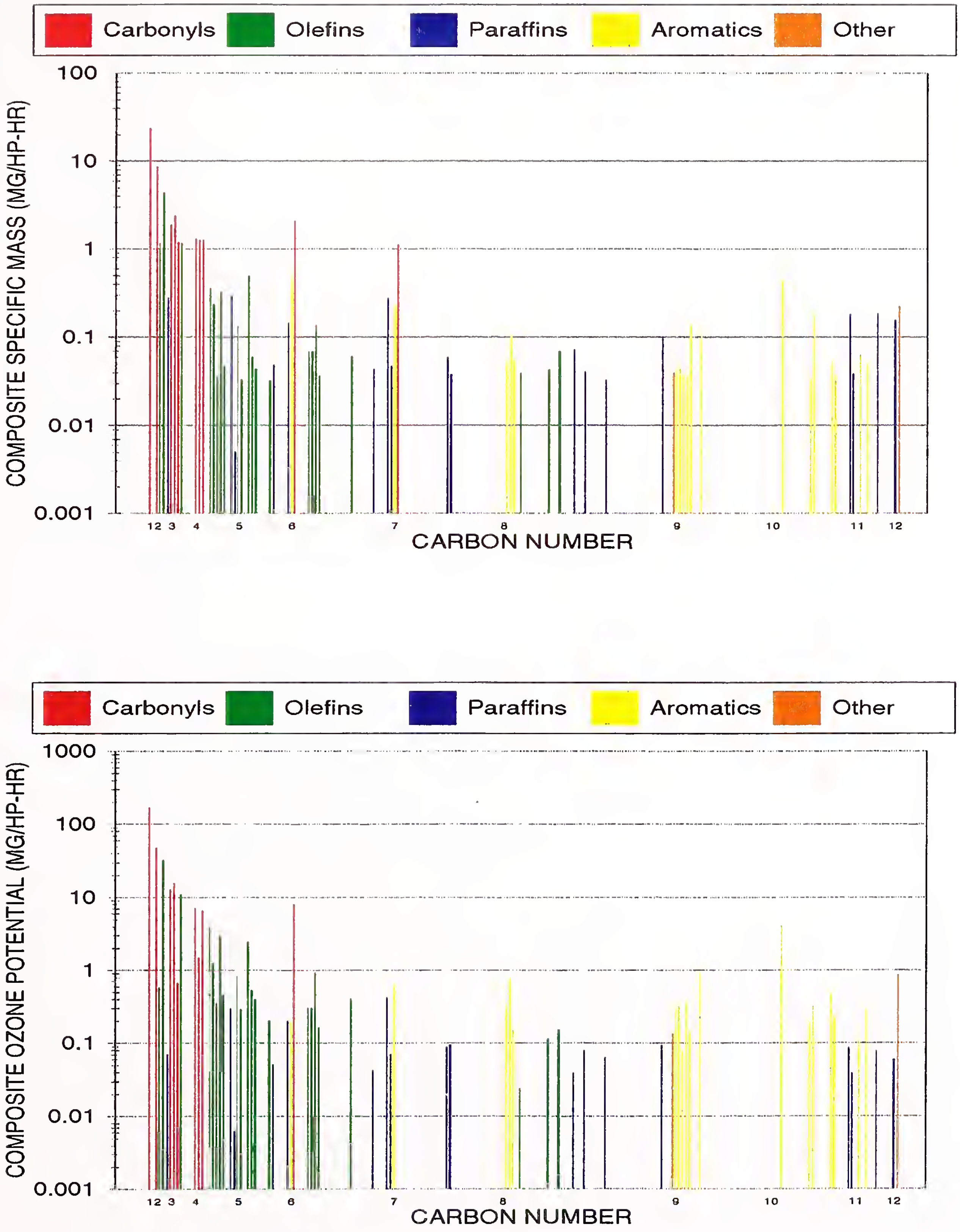
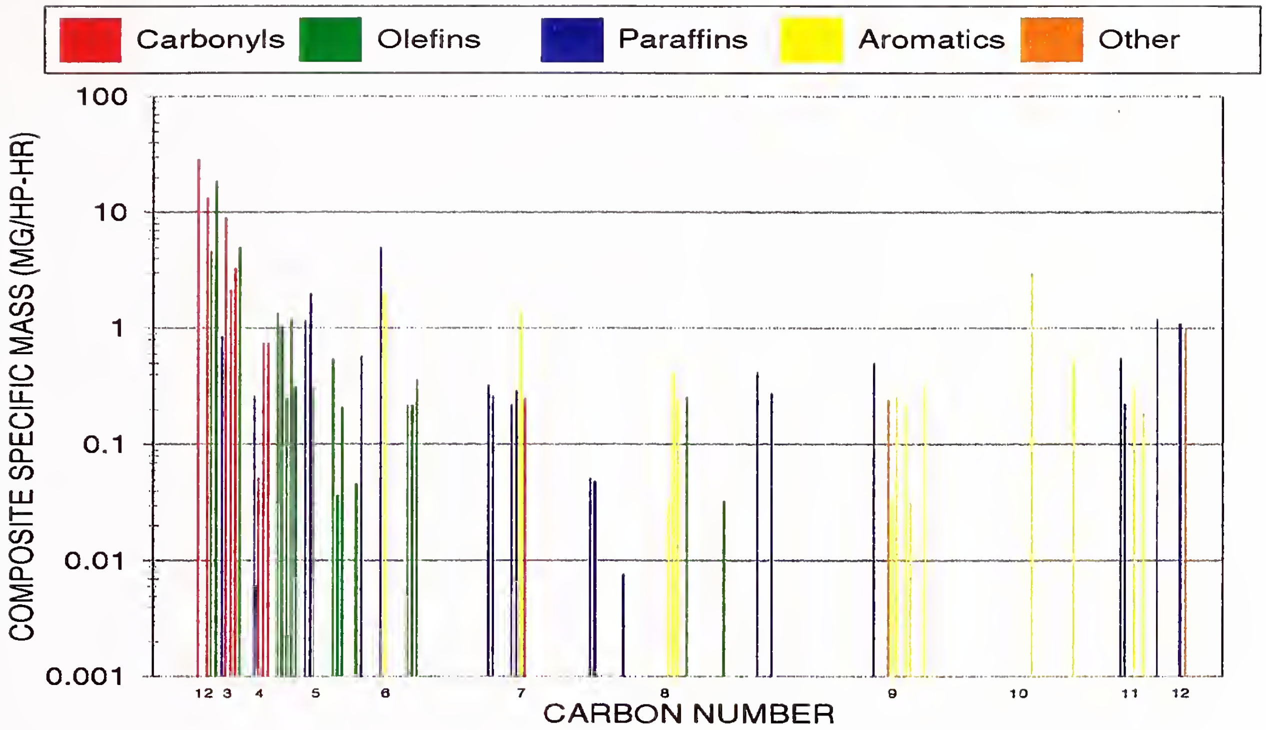


**FIGURE C-13. C1 - C12 SPECIATION DATA FOR RME20 WITHOUT CATALYST**



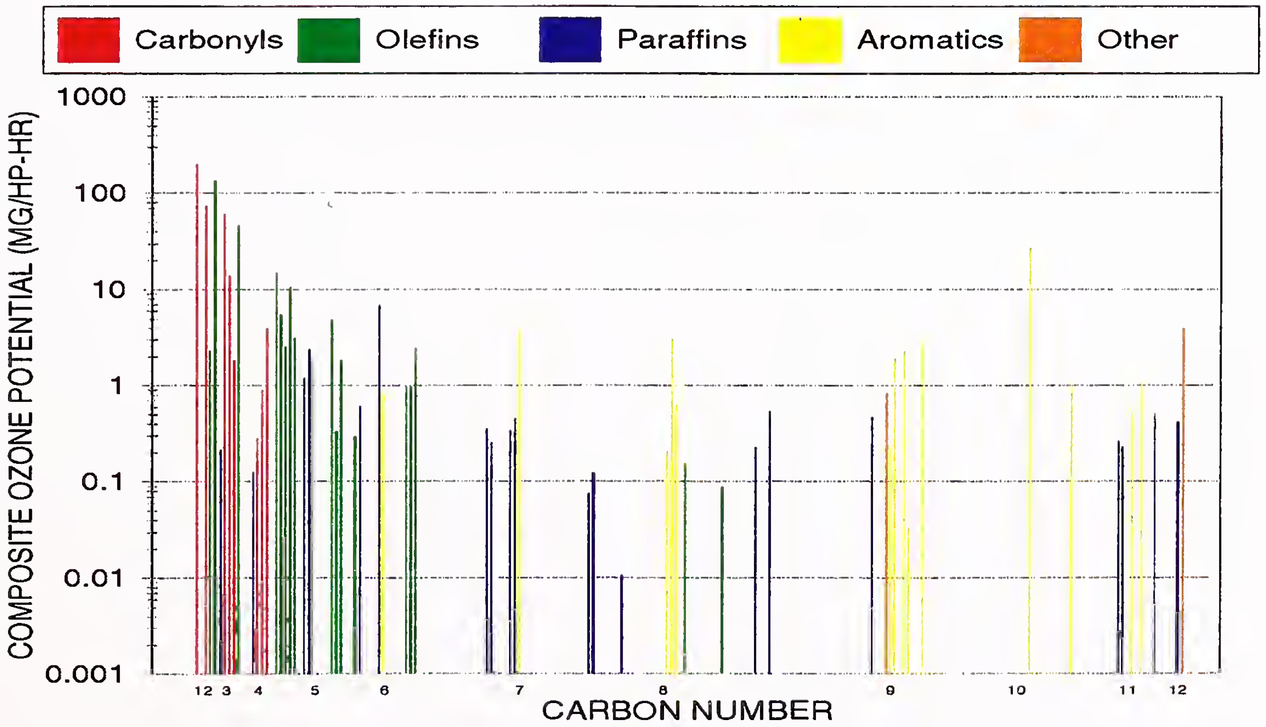


**FIGURE C-14. C1 - C12 SPECIATION DATA FOR RME20 WITH CATALYST**

# APPENDIX D

# PAH SUMMARY ASSESSMENT

# PAH Summary Assessment

## Introduction

Data for polycyclic aromatic hydrocarbons (PAH) from diesel fuel combustion were reviewed to determine if important differences could be attributed to fuel type. Acenaphthene, 1-nitropyrene and dibenzo(a,h)anthracene were reported as 0.000, so these compounds were not included in the assessment. All the fuel combinations produced some levels of the remaining PAHs. The difference is in the amounts.

## Background

Benzo(*a*)pyrene has been classified as a probable human carcinogen. However, U.S. EPA has not established a Reference Dose (RfD) or a Reference Concentration (RfC) for PAH or benzo(*a*)pyrene. Due to the findings in studies done with benzo(*a*)pyrene, this compound has the lowest ranking in exposure concentration. Benzo(*a*)pyrene has a NIOSH (recommended exposure limit) REL of about 10 ppb or 0.1 $mg/m^3$. This is an 8- or 10-hour time-weighted-average exposure and/or ceiling.

There is other evidence that suggests the remaining PAH compounds also present some degree of health risk. Several of the other PAHs, including benz(a)anthracene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, have caused tumors in laboratory animals by the oral, dermal or inhalation routes.

## Assessment

Compounds for which levels were reported as zero were dropped from the assessment. These were acenaphthene, 1-nitropyrene and dibenzo(a,h)anthracene. The remaining compounds were grouped into three categories:

1. Probable human carcinogen, benzo(*a*)pyrene
2. Suspect compounds: benz(a)anthracene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene
3. Remaining compounds: naphthalene, acenaphthylene, fluorene, fluorenone, phenanthrene, anthracene, fluoranthene, pyrene, benzo(e)pyrene and benzo(g,h,i)perylene

The assessment consisted of comparing the extremes of 3 fuel types. The category selected was 100 percent diesel versus 100 percent biofuels with no catalysts (A-C1, B-C1, C-C1).

For the first assessment, this approach did not seem suitable for the examination of three data points, and this first comparison did not show any differences, with diesel fuel in the middle. The remaining relatable combinations of 100 percent biofuel versus 100 percent diesel fuel were examined (Table D-1) (fuel types A, B, C: -C1, C-C1, - H1, and C-H1). These data indicated that the level of benzo(*a*)pyrene from both the biofuels exceeded that measured from the diesel fuel.

## APPENDIX TABLE D-1. ASSESSMENT 1

| | Fuel | Catalyst | Benzo(a)pyrene, ppb |
|---|---|---|---|
| A-C1 | 2-D | No | 3.12 |
| A-H1 | | No | 0.14 |
| AC-C1 | | Yes | 1.13 |
| AC-H1 | | Yes | ND |
| B-C1 | REE | No | 3.21 |
| B-H1 | | No | 0.95 |
| BC-C1 | | Yes | 1.82 |
| BC-H1 | | Yes | 0.56 |
| C-C1 | RME | No | 2.85 |
| C-H1 | | No | 0.64 |
| CC-C1 | | Yes | 1.77 |
| CC-H1 | | Yes | 0.44 |
| ND = Not Detected | | | |

The second assessment (Table D-2) for comparison of A-C1, B-C1, and C-C1 displayed the opposite trend. The biofuels produced lower levels of these compounds than the equivalent diesel fuel combination for all the PAH in this category.

The third assessment (Table D-3) supports the findings of the second assessment for the A-C1, B-C1, and C-C1 comparison. The biofuels produced fewer of these PAHs than the diesel fuel except for benzo(e)pyrene and benzo(g,h,i)perylene, which were among the highest molecular weight compounds in this group.

## APPENDIX TABLE D-2. ASSESSMENT 2

| Compound, ppm | 2-D | REE | RME |
|---|---|---|---|
| Chrysene | 0.00626 | 0.00365 | 0.00348 |
| Benzo(a)anthracene | 0.00493 | 0.00276 | 0.00280 |
| Benzo(b)fluoranthene | 0.00502 | 0.00385 | 0.00294 |
| Indeno(1,2,3-cd)pyrene | 0.00231 | 0.00119 | 0.00174 |
| Benzo(k)fluoranthene | 0.00439 | 0.00367 | 0.00330 |

## APPENDIX TABLE D-3. ASSESSMENT 3

| Compound, ppm | 2-D | REE | RME |
|---|---|---|---|
| Naphthalene | 1.5463 | 0.8637 | 1.0088 |
| Acenaphthylene | 0.4364 | 0.1971 | 0.1702 |
| Fluorene | 0.3801 | 0.0621 | 0.0364 |
| Fluorenone | 0.2456 | 0.0490 | 0.0261 |
| Phenanthrene | 0.7367 | 0.1728 | 0.1014 |
| Anthracene | 0.0680 | 0.0199 | 0.0137 |
| Fluoranthene | 0.6652 | 0.4140 | 0.3679 |
| Pyrene | 0.0938 | 0.0501 | 0.0492 |
| Chrysene | 0.0063 | 0.0036 | 0.0035 |
| Benzo(e)pyrene | 0.0029 | 0.0032 | 0.0027 |
| Benzo(g,h,i)perylene | 0.0023 | 0.0030 | 0.0025 |

### Summary

There appears to be differences in the concentration profiles of PAHs produced by the fuel types. This data set indicates that diesel fuel produces the lowest levels of the most potent (identified) compound, benzo(*a*)pyrene. However, the same data set indicates the biofuels produce lower levels of almost everything else. These assessments were based on an examination of the data, not a statistical analysis. However, the trends observed would probably benefit by at least a nonparametric analysis and further examination of the data.

# APPENDIX E

# DOE PACIFIC NORTHWEST AND ALASKA REGIONAL BIOENERGY PROGRAM MONTANA PROJECT SUMMARY SHEET

## DOE Pacific Northwest and Alaska
## Regional Bioenergy Program
## Montana Project Summary Sheet

1. **Title: Comprehensive emissions and chemical characterization of rapeseed oil-derived biodiesel in support of the *Truck in the Park Project***

2. **Description:** The project promotes commercial acceptance and development of rapeseed ethyl ester and rapeseed methyl ester as a biodiesel by providing definitive emissions and performance data from tests conducted by an industry-accepted laboratory. Of special interest are the results from the hydrocarbon speciation and air toxic emissions. The target audience includes regulators and heavy duty diesel users, especially in environmentally sensitive applications such as the tourism industry's buses and trucks. The Montana Department of Environmental Quality (**DEQ**) in cooperation with the U. S. Department of Energy (**DOE**) Regional Bioenergy Program, Cummins Engine Company and Dodge Truck Division of the Chrysler Corporation are developing data needed by potential markets and producers of rapeseed-based ethyl or methyl esters now produced by the University of Idaho (**UI**) and private cooperators. DEQ coordinated the testing, industrial participation, selection of vegetable oil derivatives and blends for testing, and contracted with Southwest Research Institute for the EPA heavy duty emissions tests using a Cummins B Series (5.9 liter) diesel engine. The biodiesel products also were evaluated for their lubrication qualities. The results of this testing will assist the **Truck in the Park Project** in identifying a niche market for biodiesel in the tourism industry. If successful, the project will provide data to support an initial market for a new value-added industry that uses agricultural products and wastes for feedstocks.

3. **Grantee:** Montana Department of Environmental Quality, Energy Division
Contact: Howard E. Haines, Jr. E.I.T., Bioenergy Engineering Specialist
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4. **Project Manager: Jeffrey W. James, Program Manager**
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**Phone 206-553-2079, FAX 206-553-2200**
**Identification No:** EDG-93-7549, DE-FG79-82BP35776MOD08

| | | |
|---|---|---|
| 5. | **Regional Program Funds:** | **$ 90,000** |
| | **Estimated total cost:** | 270,000 |

6. **Cost Sharing and Project Participants:**

| | |
|---|---|
| Montana Department of Environmental Quality | 135,000 |
| Dodge Truck Division of Chrysler Corporation [technical oversight] | |
| Cummins Engine Company [test engine, technical oversight] | 10,000 |
| J.R. Simplot Company, Boise, ID [ethanol and catalyst for biodiesel] | 10,000 |
| Koch Agricultural Services Company, Great Falls, MT [rapeseed oil feedstock] | |
| University of Idaho, Agricultural Engineering Department (UI), technical support, fuel production and analysis | 15,000 |
| Southwest Research Institute [vapor phase PAH investigations, technical assistance] | 10,000 |

7. **Needs Addressed:** To increase commercial acceptance of rapeseed-based biodiesel, DEQ is developing detailed data needed by regulators, potential fuel producers, diesel engine manufacturers, and consumers to support the marketing and use of bio-based petroleum substitutes.

The petroleum substitute being investigated is a locally produced rapeseed ethyl ester (REE) used as a diesel fuel additive to reduce emissions, odors, and smoke from diesel engines. Demonstrations show that REE used in a Cummins 5.9 liter diesel engine pickup reduces smoke, CO, HC, and $NO_x$, with a slight increase in particulates (PM). The cost of REE can become more competitive with other emissions reduction options if biodiesel can also be shown to reduce toxic air emissions and improve other aspects of conventional diesel fuel. Preliminary test results indicate that blends of biodiesel with conventional diesel can reduce lubricity problems observed with low sulfur diesel fuels. Also, data from Austria suggest that toxic air contaminants are reduced by using these oils blended with conventional diesel fuel. To assist commercialization of RME and REE in the United States, tests needed to be conducted using scientific and engineering practices accepted by American regulators and industry.

8. **Project Objectives:** The project objective is to obtain definitive data on emissions and other aspects of rapeseed-derived biodiesel needed for development. Commercial developers are interested in data that show biodiesel's abilities to:

- reduce the amount and type of emissions, particularly PAH and toxic air contaminants
- produce or prevent deposits on fuel injectors (detergent properties)
- increase cetane number and oxygen content in the diesel fuel

- improve the performance of lubrication oil's oxidation resistance and neutralization capacity, and
- increase the lubricity of low sulphur diesel fuel.

The tests were designed to determine:

- the biodiesel blends that best reduce emissions of carbon monoxide (CO), particulate matter (PM), oxides of nitrogen ($NO_X$), sulfates, and hydrocarbons (HC), including polycyclic aromatic hydrocarbons (PAH) and toxic air contaminants
- the effects of these biomass fuels on engine lubrication, injector carboning, engine lubrication oil and other reliability factors
- how the effects of these fuel blends apply to other heavy duty diesel engines used in buses and trucks, important if these blends are to be used in other engines.

9. **Approach:** This information was sought through comprehensive environmental and chemical testing that detects the effects of bio-based fuels on emissions, lubrication oil and engine endurance. Testing is progressing in three phases, but only Phase I is complete at this time.

Phase I: **Engine Dynamometer Testing**: Phase one consisted of EPA heavy duty engine dynamometer tests using a Cummins B Series (5.9 liter) diesel engine. This engine was selected because of past emissions tests using rapeseed-based biodiesel fuels Also, it is the same engine type used in the Truck in the Park Project. Seven fuels were evaluated: 1) Phillips low sulfur 2-D diesel fuel, 2) 100 percent rapeseed ethyl ester (REE), 3) 100 percent rapeseed methyl ester (RME), 4 and 5) 50 percent blends of REE and RME with diesel, and 6 and 7) 20 percent blends of REE and RME with 2-D diesel fuel. Besides the emissions tests, fuel analyses and a modified ball-on-cylinder or BOECLE lubricity tests were conducted on all fuels.

All heavy duty transient tests include fuel chemistry characterization of the fuel (such as cetane, density, viscosity, etc. with percent H, C and O) and analyses on regulated emissions ($NO_X$, CO, HC, and PM), soluble organic fraction (SOF) and sulfates. Other chemical analyses will be run on selected samples including:

a) Polycyclic aromatic hydrocarbons (PAH) analyses to identify aromatic compounds.

b) Direct filter injection gas chromatography (DFI/GC) analysis to provide volatile organic fraction (VOF) and identify the source of emissions

c) Hydrocarbon speciation, aldehydes and ketone analyses: A CARB protocol provides data for compounds in the C1-C12 range. A speciation protocol for C13-22 was developed by SwRI to analyze diesel type fuels. This procedure provides results that are not as definitive as the C1-12 analyses partly because it is not yet a certified protocol. This testing best evaluates fuel additives, such as a blend of biodiesel with conventional diesel. Each fuel was run for one cold and two hot starts with and without the catalytic converter. Baseline fuels of low-sulfur diesel fuel and 100 percent REE (fuels A and B) were run for two consecutive days. The following emissions were collected during this testing:

- Data on $NO_X$, CO, $CO_2$, HC, and PM, soluble organic fraction (SOF) and sulfates
- Solid and volatile fraction PAH, ketones and aldehydes were analyzed for the first cold and hot starts of each fuel
- Solid and volatile fraction emissions had a bioassay and PAH analyses for the second hot start of each fuel
- A Volatile Organic Fraction (VOF via DFI/GC) test was run on the first cold and hot starts of each fuel
- Hydrocarbon speciation C1-22 (proposed diesel protocol) analyses were run on the first hot and cold start of each fuel

**Phase II: California Air Resource Board (CARB) Certification** tests using a Detroit Diesel Series 60 diesel engine (or equivalent): Based on the results of Phase I testing, the most promising fuels will proceed to Phase II, that will screen the fuel for compliance with the California Air Resource Board (CARB) regulations. These tests use a Detroit Diesel Series 60 diesel engine. This test would follow 2 of 10 days of the CARB Alternative 1 Certification Test using a pseudo California diesel for the reference fuel to compare two candidate fuels. The screening test would evaluate one reference and two candidate fuels. Samples would be analyzed for regulated emissions, $CO_2$, SOF, sulfates, PAH, and DFI/GC (VOF). Hydrocarbon speciation (C1-22) analyses would be performed only on the first run of each fuel. This would supply the hydrocarbon speciation data needed for EPA's fuel certification requirements.

Results of these screening tests will determine the value in conducting the complete and very expensive CARB test that runs for 10 days for each fuel with a control fuel that costs more than $100 per gallon.

**Phase III**. Based on the results of Phase II testing, the most promising fuels will proceed to Phase III, which will include standard reference tests such as a Cummins L-10 injector carboning analyses and the 1K (lube oil durability test) if need and funding permit.

## 10. Major Milestones:

- Project management and development of detailed test plan (completed 5/20/95)
- Conduct Phase I testing using a Cummins B diesel engine (completed 12/4/95)
- Review report and decide on fuels to continue testing (in progress)
- Conduct Phase II testing using a Detroit Diesel Series 60 or similar engine
- Conduct Phase III testing using the candidate biodiesel fuel in a Cummins L-10 or Caterpillar 3304 engine
- Reporting, information transfer, presentations (on-going)

## 11. Results:

- DEQ obtained private industry match for fuel and a 160 HP Cummins B5.9L engine which was delivered to Southwest Research Institute on June 12, 1995.
- The final test plan addressed problems found in other reported testing. Two analyses were used to clarify the carbon source (fuel or lube) and type of compounds. First, particulate samples were analyzed with a mass spectrogram performed to identify the compounds--a qualitative measure used to calibrate gas chromatographies (GCs) to monitor those compounds quantitatively. Second, a direct filter injection gas chromatograph (DFI/GC) analysis identified the source of hydrocarbon compounds: either the lubrication oil or fuel. A DFI/GC is neither a gas chromatograph nor mass spectrogram, but identifies compounds from unburned or partly burned lube oil. These tests, coupled with hydrocarbon speciation of C1-22, provide a detailed look at emissions from rapeseed-based biodiesels.
- In September 1995, four barrels each of REE and RME were shipped to SwRI. Jeff Taberski, of the University of Idaho, monitored the blending and test cell set up at SwRI. The fuels were blended, and fuel characterization data completed.
- A Cummins B5.9L diesel engine was installed for Phase I tests which started October 23 and were completed on December 4, 1995.
- The original test plan assumed that hydrocarbon speciation (C1-C22) would yield data adequate to report part results. However, the sampling temperatures for hydrocarbon speciation and volatile PAH were different requiring a separate sample and analysis. The changes were made before any tests were run. Also, at this time, another set of samples was collected for bioassay analyses by the University of California at Davis using16

"cleaned" EPA poly-urethane foam air filters or PUF samples were taken on the second hot run of each fuel.

- On March 14, 1996, DEQ distributed for review a draft final report regarding the work at SwRI. The final printing of the report was ordered December 6, 1996. A summary of the work is in the report's Executive Summary.

## 12. Reports

- Sharp, Christopher A., Howard E. Haines. November 1996. **Emissions and Lubricants Evaluation of Rapeseed Derived Biodiesel Fuels.** EDG-93-7549, SwRI 7507. Montana Department of Environmental Quality. Helena, Montana.

## 13. Future Activities

- As a result of the testing to date, a few items have been recommended for further study. These include:

  A. The results of the lubricity testing showed that the rapeseed esters dramatically improved low-sulfur diesel's lubricating properties. The final report recommends that lubricity testing of rapeseed ethyl ester at concentrations of 1, 2 and 5 percent be conducted to reveal its impact on lubricity of low sulfur and California Diesel. However, this rough data was indicative of biodiesel's commercial viability as a lubricity additive. It is now being marketed as such in the eastern United States.

  B. The carbon residue test we used was designed for petroleum diesel fuels and does not provide a repeatable result from biodiesel fuels. This is partly due to biodiesel having a narrow distillation temperature range. Review of the literature showed that the Caterpillar company recommended a different carbon residue test (ASTM-D189, CAR) for a more accurate comparison of diesel and biodiesel fuels and blends. DEQ also ran this test on all test fuels.

  C. Injector carboning tests are being considered to identify just how the heavier viscosity, slower burn rate, and different droplet size of biodiesel affects combustion and how the fuel may be altered to reduce or eliminate any problems.
- Decide what additional tests are needed, and get additional match.
- Finish bioassay analysis at University of California, Davis.

**14.** Date Prepared: April 17, 1995
Date Amended: December 6, 1996